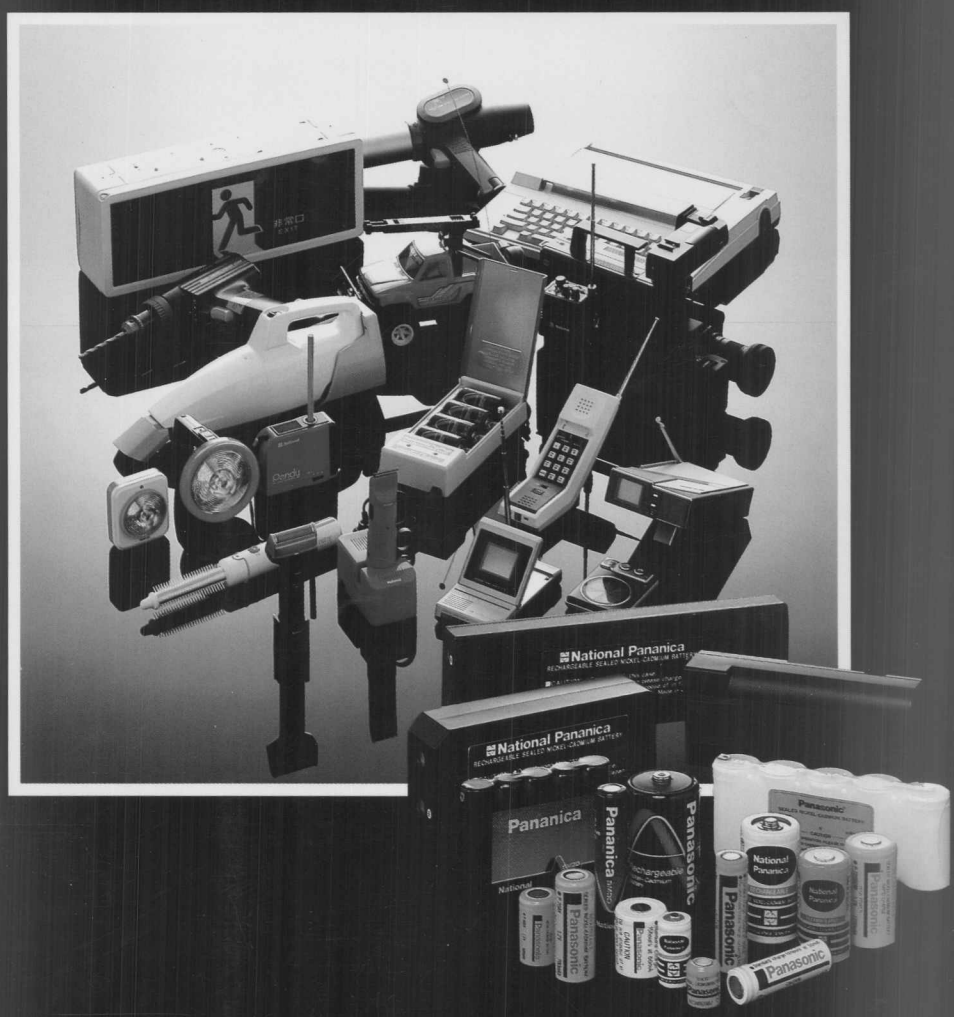
National

NICKEL CADMIUM BATTERIES TECHNICAL HANDBOOK



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Shonan/Osaka Plants

As the most advanced plants of Ni-Cd Battery Division, there new Shonan and Osaka plants were built in pursuit of excellence for nickel cadmium batteries employed in any applications worldwide. National is seeking to make the highest quality products in these plants to serve the people of the world.

The data in this handbook are intended as general information and correspond to the technical status at the time of printing, Matsushita Battery Industrial Co., Ltd. reserves the right to change any data or status without notice.

1. General Information

1.1. General Features

The National nickel-cadmium battery, is a rechargeable sealed nickel-cadmium alkaline cell.
Because of its perfectly sealed construction and its efficient charge/ discharge characteristics, it provides superior features and practical value not found in primary or other secondary cells. Unlike primary cells that can be used only once, rechargeable cells can be recharged repeatedly, so that they can be used once again. In addition to this charge/discharge feature, rechargeable cells have a long shelf life and a stable voltage. The National Ni-Cd cell employs an original plate manufacturing process and construction developed by Matsushita. It not only makes possible repeated charging and discharging, but also makes it resistant to shelf-life deterioration, thus prolonging its useful life. These features make the National Ni-Cd cell extremely reliable and economical.
During the manufacturing process, thorough quality control measures are rigidly enforced. **Each cell is computer tested for voltage, capacity and internal resistance,** and external appearance is physically examined. **Only those cells which pass these high quality and reliability standards are shipped to our customers.**

1.2. Features of National Cells

■ Long Life

The cell can provide more than 500 charge/discharge cycles. This makes it extremely economical, and provides an expected life similar to that of the device in which it is used.

■ Excellent Discharge Characteristics

National nickel cadmium batteries feature low internal resistance and high, flat voltage characteristics during high current discharge. Compared with conventional models, these products have a higher capacity and charge more rapidly. With the highest energy-density of any Ni-Cd battery in the world, they offer unsurpassed discharge characteristics suitable for a wide variety of applications.

■ Long Shelf Life

The National Ni-Cd cell provides long storage life with few limiting conditions. It offers problem-free charging after long storage, permitting use in a wide range of applications.

■ High-Rate Charging

For those applications which require it, the cells can be quick charged or rapid charged in 1 ~ 6 hours, using the appropriate charging circuits.

■ Wide Temperature Range

Discharge characteristics are superior, even under low-temperature conditions. Cells for high-temperature operation exhibit superb charging efficiency and long life, and in some applications can be used above 65°C.

■ Reliable, Self-Resealing Vent

Each cell is equipped with a self-resealing safety vent which provides high reliability during long-term use or in the event of charger malfunction.

■ Sealed, Strong, Leakproof Construction

Sealed construction, with no water addition required, provides safety and maintenance-free service. The cell can be used in any desired position during charge, discharge or storage conditions. Due to the special material used for the gasket, and the use of our original liquid sealing compound, there is no liquid leakage!

1.3. Applications

■ For Cyclic Use

Consumer Applications
Shavers, portable VTRs (VCRs), radios, televisions, tape recorders, portable computers.

Communication and Telephone Equipment
Cordless and portable telephones, transceivers, pocket pagers, car telephone systems.

Office Equipment
Portable calculators, electronic cash registers, printers, typewriters.

Tools
Grass and hedge trimmers, cordless drills, screwdrivers, hammer drills, saws.

Instruments and Medical Equipment
Electronic instruments, measuring equipment, medical electronics, heart defibrillators.

Photography
Electronic cameras, strobo, VTR and movie lights.

Toys and Hobby
Radio-controllers, model motor driving, lights.

■ For Trickle or Float Charge Use

Emergency Devices
Lights, fire and burglar alarms, communication systems, fire shutters.

Memory Backup
Electronic cash registers, computers, sequencers, memorychips.

1.4. Construction

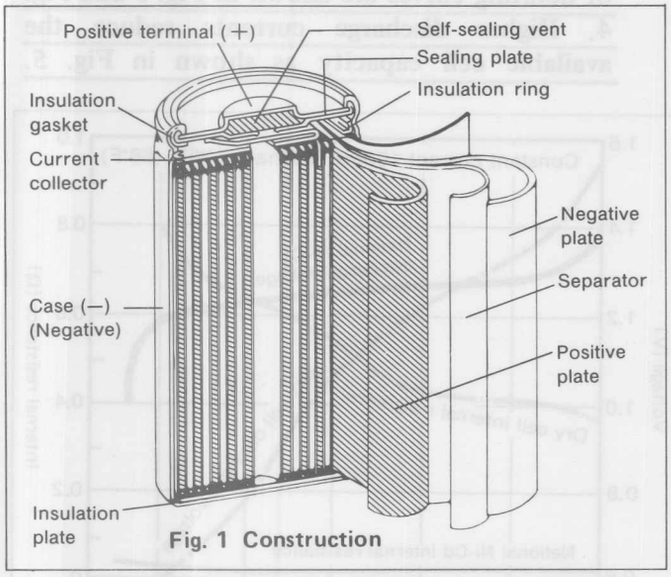


Fig. 1 Construction

(A) All National Ni-Cd cells are cylindrical. Using National's original manufacturing process, the positive is sintered and the negative is pasted. This unique construction yields high productivity, superior gas absorption, and high capacity and eliminates "memory effect". The National cell consists of positive and negative plates, separator, alkaline electrolyte, metal case, and sealing plate with self-resealing safety vent. (Fig. 1)

(B) The positive plate is a porous, sintered nickel plate, filled with nickel hydroxide.
The negative plate is a punched plate of thin steel, coated with cadmium active material.

(C) The separator is made of a polyamide fiber or, for high temperature applications, a non-woven polypropylene fiber. The positive, separator and negative are automatically sandwiched together, wound into a coil and inserted in the metal case.

(D) The electrolyte is an alkaline aqueous solution which is totally absorbed into the plate and separator. The metal case is constructed of nickel-plated steel, welded internally to the negative plate. It becomes the negative pole.

(E) The sealing plate, uses a special liquid sealing agent in order to form a perfect seal. The positive is welded internally to the sealing plate, so that it becomes the positive pole. The self-resealing safety vent permits the discharge of gas in the event of an abnormal increase of internal pressure. This prevents the possible danger of a rupture or other damage. The vent uses a special alkaline and oxidation resistant rubber to assure the retention of its operating pressure and safety characteristics over a long period of time.

1.5. Electrochemical Processes

(A) The electrochemical processes of nickel-cadmium alkaline storage cells are described below:

[Positive] [Negative] [Electrolyte] [Positive] [Negative]

$$2NiOOH + Cd + 2H_2O \underset{\text{Charge}}{\overset{\text{Discharge}}{\rightleftarrows}} 2Ni(OH)_2 + Cd(OH)_2$$

[Oxy-Nickel hydroxide] [Cadmium] [Water] [Nickel hydroxide] [Cadmium hydroxide]

In this process, charging and discharging are reversed with high efficiency, with the electrical energy used during discharge being regained during recharge.

(B) In the final stage of charging, an oxygen gas generation reaction occurs at the positive:

[Positive] $4OH^- \rightarrow O_2 \uparrow + 2H_2O + 4e^- \ldots\ (1)$

[Hydroxide ions] [Oxygen] [Water] [Electrons]

This oxygen passes through the separator to the negative, after which an absorption reaction occurs at the negative and absorption takes place.

[Negative] $O_2 + 2H_2O + 4e^- \rightarrow 4OH^- \ldots\ (2)$

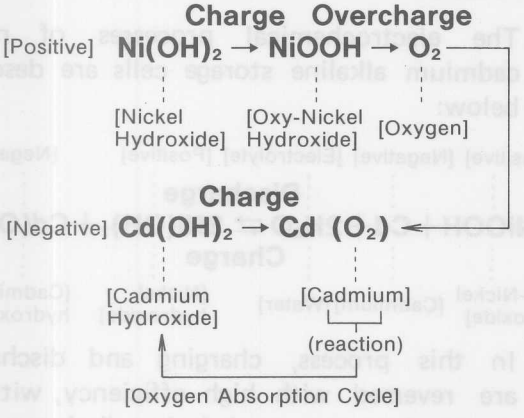
[Oxygen] [Water] [Electrons] [Hydroxide ions]

Because the oxygen gas generated in the final stage of charging is absorbed by the negative, as shown by equations (1) and (2), there is no increase in internal pressure, despite the sealed construction. When, however, the charging current exceeds the specified value, or when charging is conducted at less than the specified temperature, the amount of gas generated by

reaction (1) cannot all be absorbed by reaction (2). In that event, an increase in internal pressure develops, and, in the worst case, the safety vent is activated.

(C) It should be noted that when the safety vent functions, electrolyte is consumed and performance deteriorates. To prevent or reduce this, it is important that charging be conducted under recommended conditions. The quick and rapid charge National cell, uses an improved negative plate. As a result, the reaction speed of (2) is amplified, and the oxygen gas is absorbed more effectively at high charging current levels.

(D) The above gas generation and absorption reactions can be experessed as follows.



1.6. General Characteristics

National offers a wide range of cells for varying applications and requirements:

- Standard
- Rapid Charge "R"
- High Temperature "H"
- High Capacity "E"
- High Rate Discharge & Rapid charge "R/P"
- Super High Capacity & Rapid Charge "S"
- Memory Backup
- Consumer Type

The following explanation of their characteristics is centered around the Standard type. (This book outlines general capabilities. For more detailed information or assistance, please contact National)

1.6.1. Discharge

(A) The discharge characteristics of National Ni-Cd cells are extremely flat when compared to those of dry cells. The initial power of a dry cell is 1.5V, whereas that of the National Ni-Cd cell is 1.2V. But, as shown in Fig. 2, the voltage of the National cell is higher for the largest portion of the discharge curve.

(B) Discharge voltage characteristics depend upon discharge current and temperature. Examples of derating curves are shown in Fig. 3 and Fig. 4. Higher discharge currents reduce the available cell capacity as shown in Fig. 5.

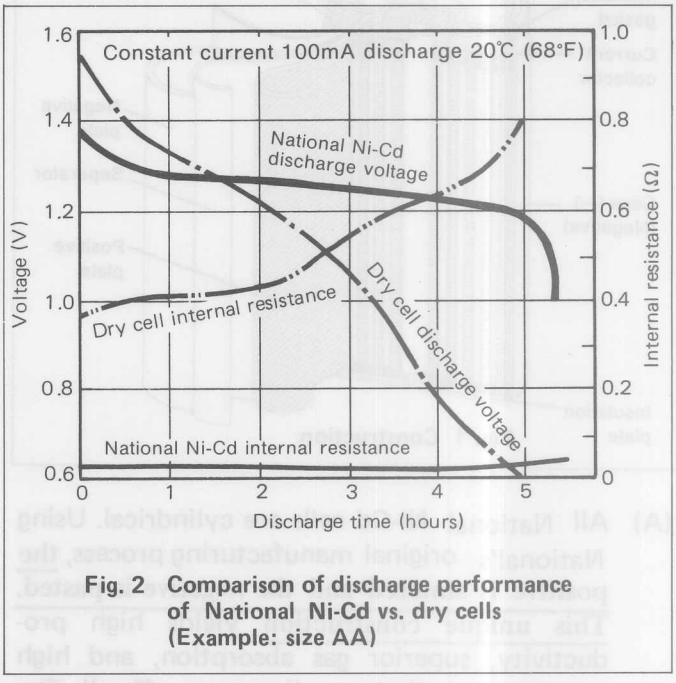


Fig. 2 Comparison of discharge performance of National Ni-Cd vs. dry cells (Example: size AA)

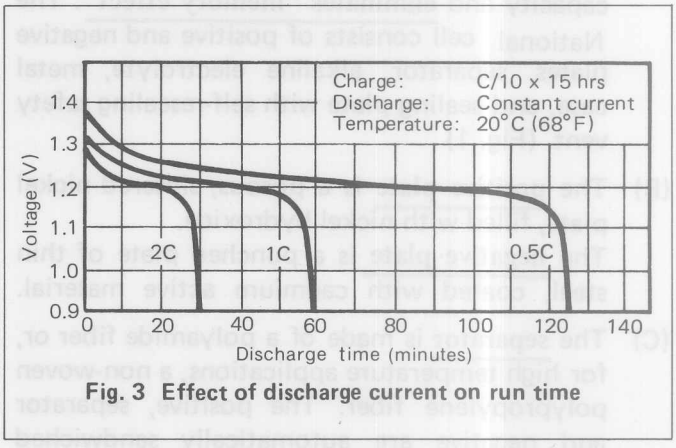


Fig. 3 Effect of discharge current on run time

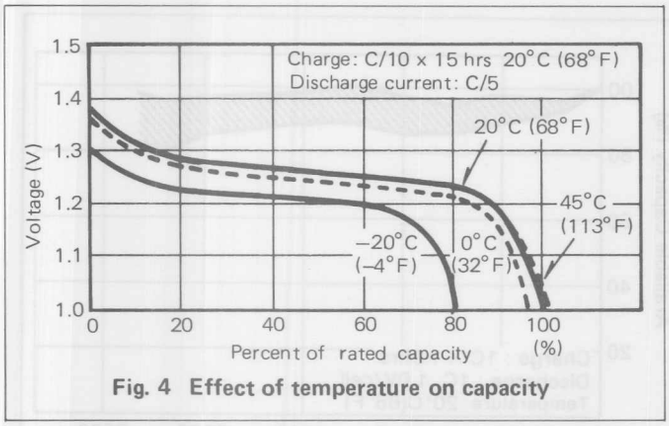


Fig. 4 Effect of temperature on capacity

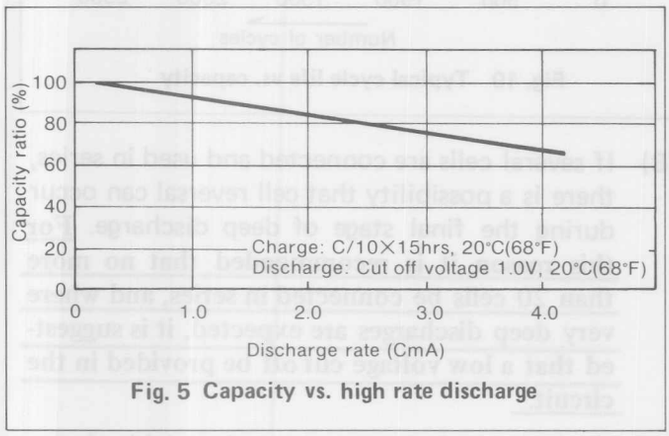


Fig. 5 Capacity vs. high rate discharge

1.6.2. Charge

(A) The cell voltage varies with charging current and temperature (Fig. 6), but is usually within the range of 1.3 to 1.6V/cell. At the standard charging current (C/10), there is almost no increase in the final voltage at 45°C (113°F). But at 0°C (32°F), it can be seen that the voltage may decrease slightly after charging is completed.

(B) Although National cells can be continuously charged within the range given in the individual data sheets, the following guide is given for longest life:

Standard charge:	C/10	14~16 hours	All types
Quick charge:	C/3~C/4	4~6 hours	Standard types, sub C and smaller
Rapid charge:	1~1.5C	1~1.5 hours	"R" type
Trickle charge: (Float)	C/20~C/30	Continuous	All types
Minimum:	C/30	Continuous	All types

(C) Quick charging characteristics are shown in Fig. 7.

(D) Rapid charging characteristics are shown in Fig. 8.

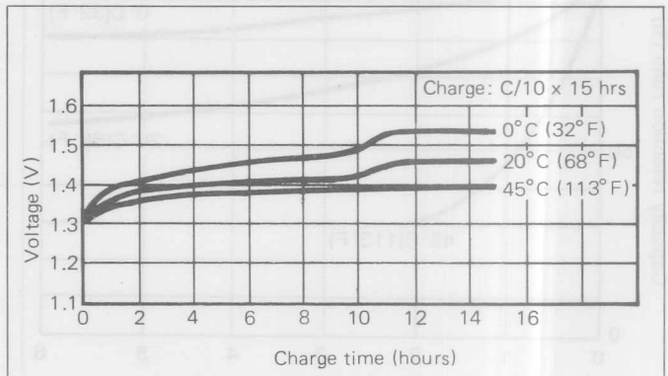


Fig. 6 Effect of temperature on standard charge

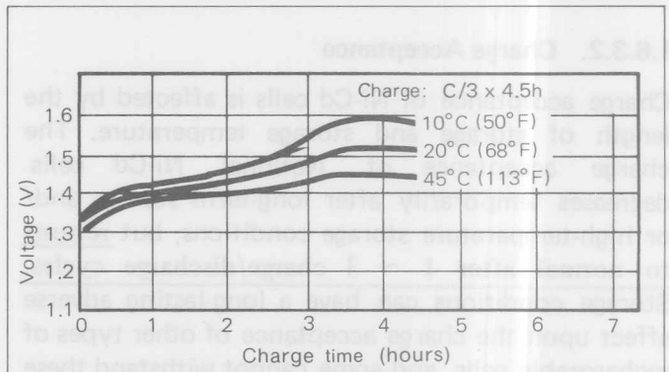


Fig. 7 Effect of temperature on quick charge

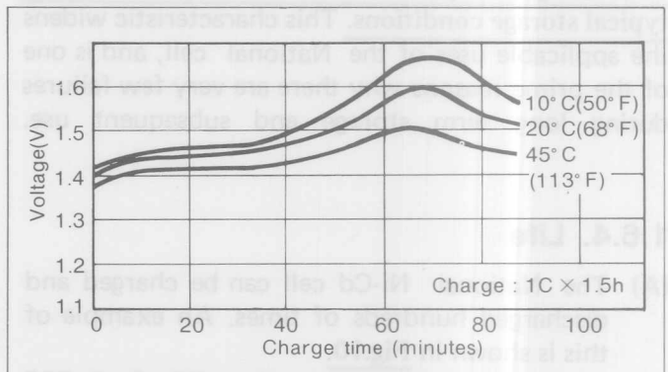


Fig. 8 Effect of temperature on rapid charge

1.6.3. Storage and Shelf Life

There are two major characteristics related to storage and shelf life. The first is capacity retention after storage, and the second is charge acceptance after storage.

1.6.3.1. Capacity Retention (Self-discharge)

Capacity retention varies widely with ambient temperature, and decreases at higher temperatures (Fig. 9).

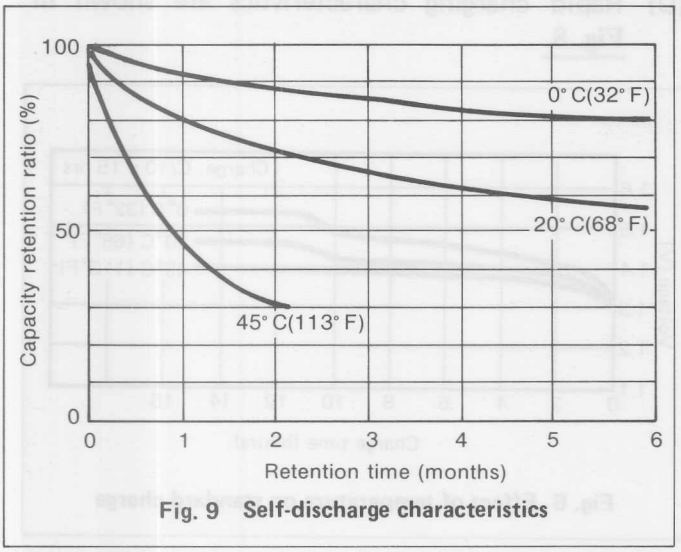


Fig. 9 Self-discharge characteristics

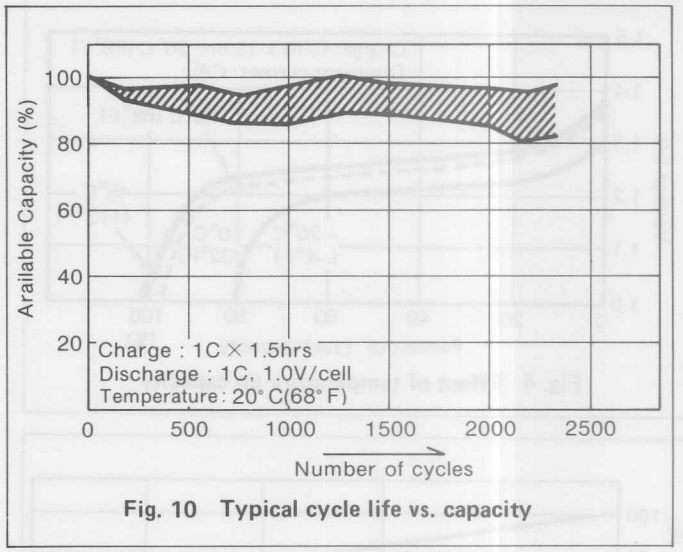


Fig. 10 Typical cycle life vs. capacity

1.6.3.2. Charge Acceptance

Charge acceptance of Ni-Cd cells is affected by the length of storage and storage temperature. The charge acceptance of National Ni-Cd cells decreases temporarily after long-term storage and/or high-temperature storage conditions, but **returns to normal after 1 ~ 3 charge/discharge cycles.** Storage conditions can have a long-lasting adverse effect upon the charge acceptance of other types of rechargeable cells, and some cannot withstand these conditions. **However, there are virtually no problems with charge acceptance of the National cell under typical storage conditions.** This characteristic widens the applicable uses of the National cell, and is one of the prime reasons why there are very few failures during long term storage and subsequent use.

1.6.4. Life

(A) The National Ni-Cd cell can be charged and discharged hundreds of times. An example of this is shown in Fig.10.
Under normal conditions, more than 500 cycles (charge/discharge) can be expected. **The cell has reached its end of life when capacity falls bellow 80% of original rating.** Life is decreased by charge/discharge cycles beyond the specified temperature or current range, or by extended storage under conditions which exceed specified temperature limits, or by cell reversal.

(B) If several cells are connected and used in series, there is a possibility that cell reversal can occur during the final stage of deep discharge. **For this reason it is recommended that no more than 20 cells be connected in series, and where very deep discharges are expected, it is suggested that a low voltage cut off be provided in the circuit.**

(C) For information concerning the trickle charge life of National Ni-Cd cells in high temperature use, refer to section 1.6.6.2.

1.6.5. Effects of Temperature upon Performance

The standard National Ni-Cd cell has excellent discharge characteristics at normal temperatures (Fig. 4). If the temperature during charge and discharge is high, capacity tends to decrease (Fig. 11). When cells are trickle charged at a high temperature, this tendency is accelerated. **Therefore, it is recommended that special high temperature cells be used for applications in high temperature ambients (Fig. 13).**

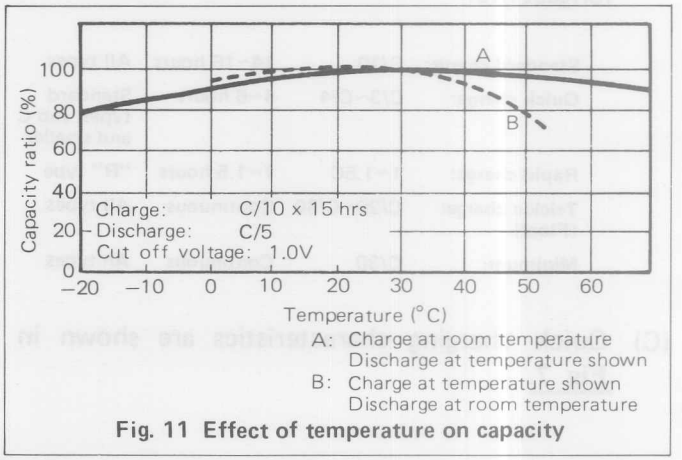


Fig. 11 Effect of temperature on capacity

1.6.6. Characteristics of Special Purpose Batteries

In order to widen the useful applications of the National Ni-Cd cell and to use its advantages to the fullest, special purpose types have been developed. Detailed characteristics of special purpose batteries are shown elsewhere as individual data. Only a summary of characteristics will be given here. There are six special types:

- Rapid Charge "R"
- High Temperature "H"
- High Capacity "E"
- High Rate Discharge & Rapid Charge "R/P"
- Super High Capacity & Rapid Charge "S"
- Memory Backup

1.6.6.1. Rapid charge "R" type

The "R" type cell has a specially improved negative plate with increased gas absorption characteristic. It can be subjected to uncontrolled charging at the 1C rate and a rapid charge in 1 to 1.5 hours is possible.

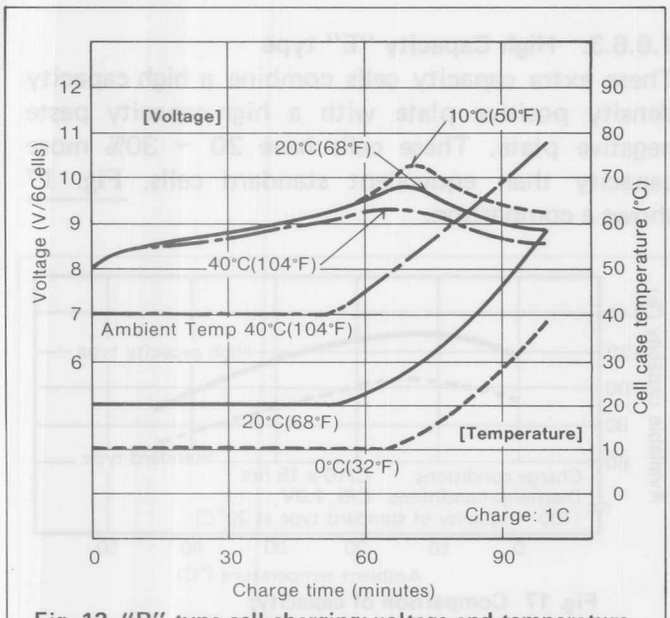


Fig. 12 "R" type cell-charging; voltage and temperature

Fig. 12 shows charge voltages and charge temperatures. Because the temperature increase is quite noticeable, it is necessary to stop the charging current when full charge is reached. **The National "R" type cell permits the detection of the voltage decrease after the charging voltage has reached its peak, and detection of the temperature increase.**

1.6.6.2. High Temperature "H" type

By using a polypropylene separator, the "H" type cell can withstand a temperature of 65°C (149°F) during use. Due to special electrolyte, when charging is conducted at a low charging current of C/20 to C/30 in a high temperature ambient, the "H" type cell has improved capacity compared to a standard cell (Fig. 13). For trickle charges, life is determined by time rather than by the number of cycles. **Life is influenced by temperature and charging current, and estimated life is shown in Fig. 14.**

- National "H" type cells for high temperature use can be classified into two types according to application: the emergency back-up type and the memory backup type.

(A) Emergency backup ("H" type)

Emergency backup normally uses DH, CH, SCH or AAH, and a trickle or float charge of C/20 to C/30 is usually applied.

(B) Memory backup ("H" type)

This applications requires less capacity, and normally uses AAH, 1/3AAH. In addition to excellent high temperature characteristics, the charge/discharge characteristics for small currents in the μA range are excellent (Figs. 15, 16, and 17). **National should be consulted if use in a temperature exceeding 65°C (149°F) is contemplated.**

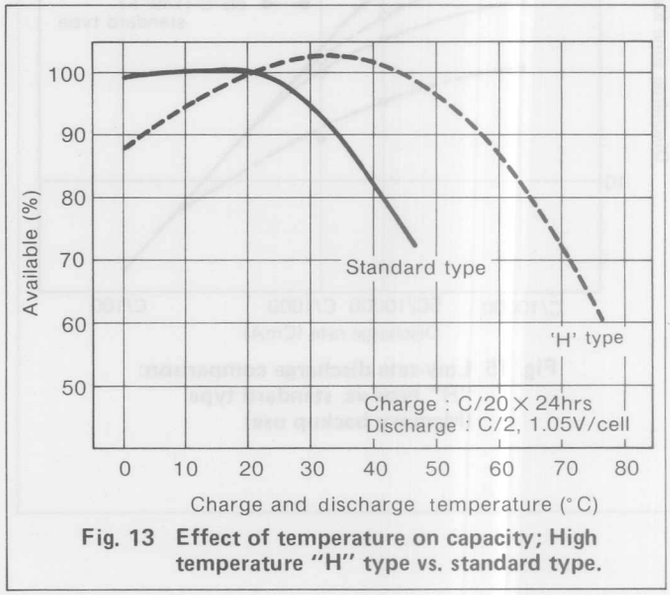


Fig. 13 Effect of temperature on capacity; High temperature "H" type vs. standard type.

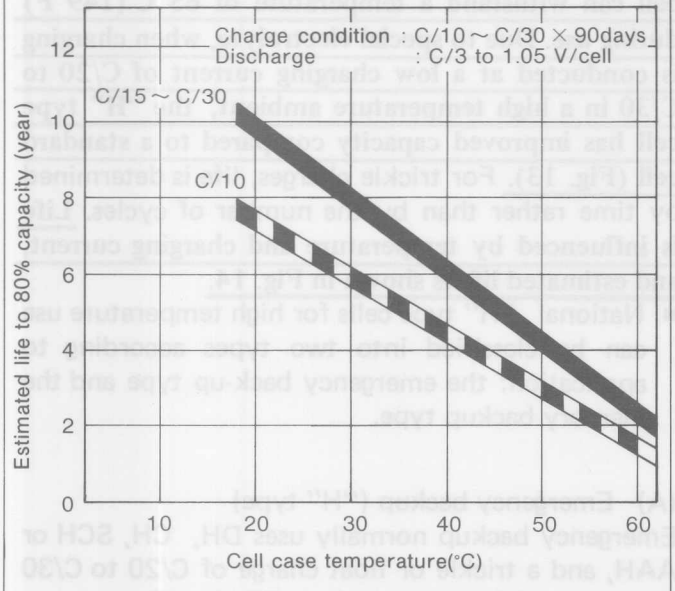


Fig. 14 Effect of temperature and charge rate on trickle life

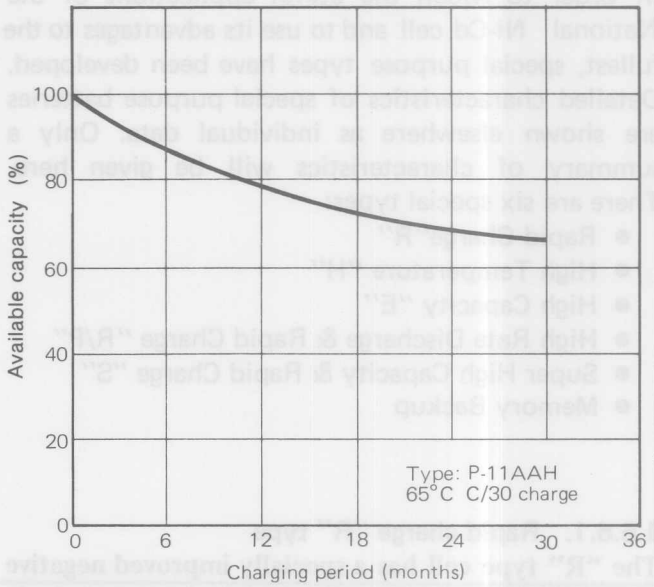


Fig. 16 Capacity of "H" type cell at high temperature 65°C (149°F) after long-term charging.

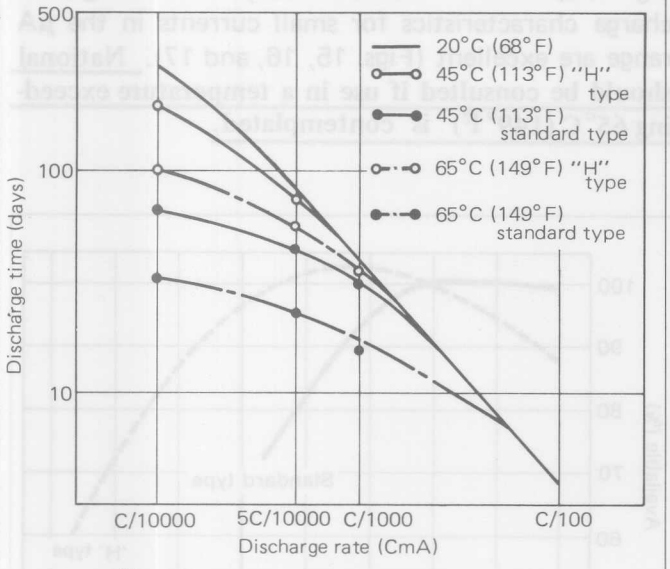


Fig. 15 Low-rate discharge comparison: "H" type vs. standard type (Memory backup use)

1.6.6.3. High Capacity "E" type

These extra capacity cells combine a high capacity density positive plate with a high capacity paste negative plate. These cells have 20 ~ 30% more capacity than equivalent standard cells. Fig. 17 shows a comparison.

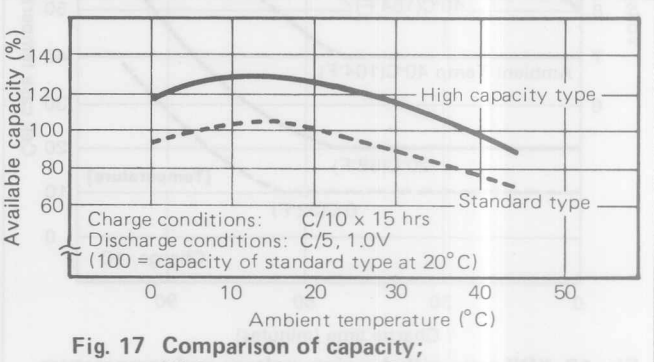


Fig. 17 Comparison of capacity; High capacity type "E" vs. standard type

1.6.6.4. High Rate Discharge & Rapid charge "R/P" type

Using edge-welded plates and terminals, the resulting cell has sharply reduced internal resistance and improved voltage characteristics during high rate discharge. Fig. 18 shows a comparison with the standard type cell. These unique plates feature gas absorption characteristics, permitting the same rapid charge as the "R" type cells (For detail, see individual sheets)

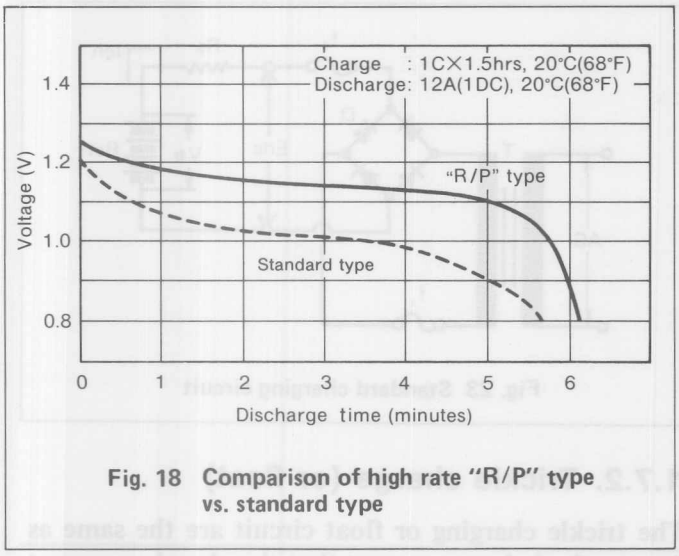


Fig. 18 Comparison of high rate "R/P" type vs. standard type

1.6.6.5 Super High Capacity & Rapid Charge "S" type.

Super High Capacity and Rapid Charge type "S" is designed to meet the demands of high capacity equipment. It can be fully charged in approximately one hour like the "R" type. The "S" type combines a high-density positive plate made of foam nickel and a pasted negative plate. **The resulting capacity is approximately 30% greater than that of the rapid-charge National "R" type battery of the same size.**

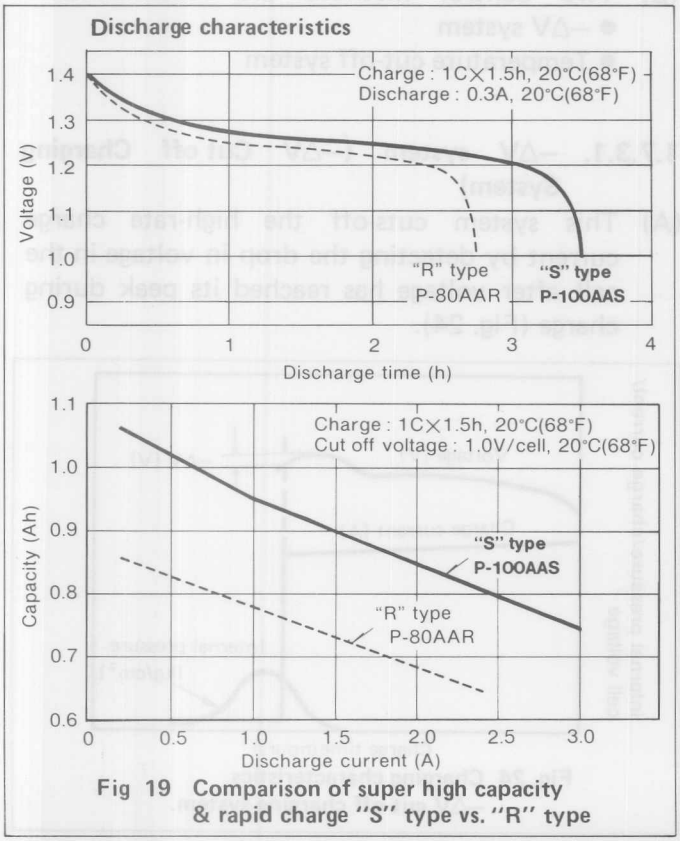


Fig 19 Comparison of super high capacity & rapid charge "S" type vs. "R" type

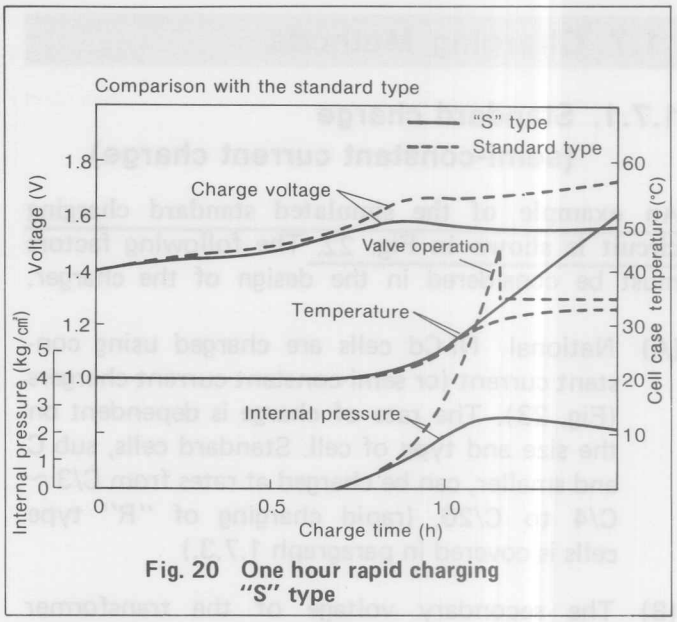


Fig. 20 One hour rapid charging "S" type

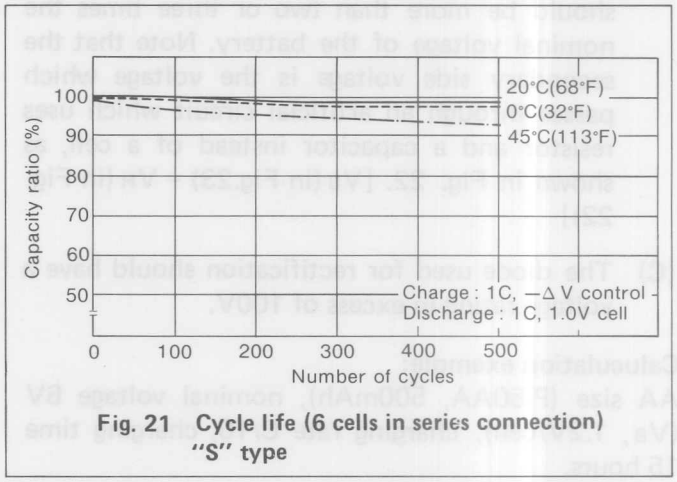


Fig. 21 Cycle life (6 cells in series connection) "S" type

Fig. 20 shows rapid charging of the "S" type, while Fig. 21 shows cycle life. For more detail, see pages 38, 39, 56.

1.7. Charging Methods

1.7.1. Standard charge (semi-constant current charge)

An example of the simulated standard charging circuit is shown in Fig. 22. The following factors must be considered in the design of the charger.

(A) National Ni-Cd cells are charged using constant current (or semi-constant current chargers (Fig. 23). The rate of charge is dependent on the size and type of cell. Standard cells, sub C and smaller, can be charged at rates from C/3 ~ C/4 to C/20. (rapid charging of "R" type cells is covered in paragraph 1.7.3.)

(B) The secondary voltage of the transformer should be more than two or three times the nominal voltage of the battery. Note that the secondary side voltage is the voltage which passes through an artificial circuit which uses resistor and a capacitor instead of a cell, as shown in Fig. 22. [V_B (in Fig.23) = V_R (in Fig. 22)]

(C) The diode used for rectification should have a voltage rating in excess of 100V.

Caluculation example:

AA size (P-50AA, 500mAh), nominal voltage 6V (V_B, 1.2V/cell), charging rate C/10, charging time 15 hours.

In Fig. 23.

Edc=V_Bx3=6Vx3=18V ..... Secondary voltage

Ich=500(mAh)x1/10=50(mA) . charging current

$$Rs=\frac{Edc-V_B}{Ich}=\frac{18V-6V}{0.05A}=240\Omega \text{ ..... resistor}$$

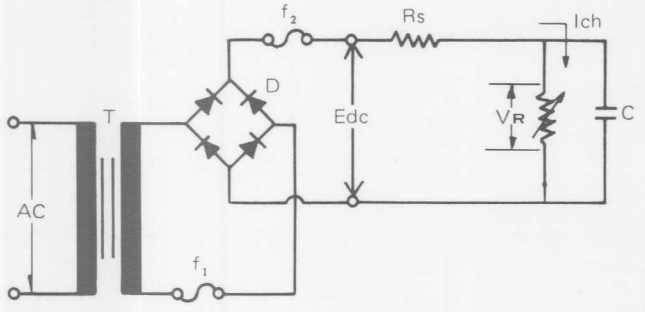


Fig. 22 Simulated standard charging circuit

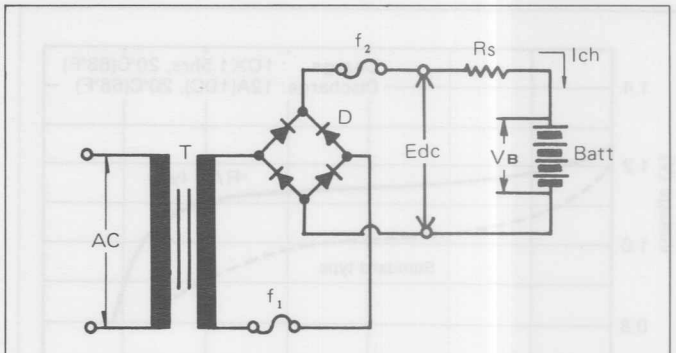


Fig. 23 Standard charging circuit

1.7.2. Trickle charge (or float)

The trickle charging or float circuit are the same as for standard charge, except that the charging current is reduced to C/20 ~ C/30.

1.7.3. Rapid-charge "R" type

(A) The "R" type National Ni-Cd cell can be rapidly charged in 1 ~ 1.5 hours using recommended charging circuits and controls. The cell is normally charged at the 1C rate for 1 ~ 1.5 hours, at which time charging current is reduced to C/10 (or less) to complete the charge. (Here, C means nominal capacity. See Individual Data.)

(B) Two control methods are recommended:
- $-\Delta V$ system
- Temperature cut-off system

1.7.3.1. $-\Delta V$ system ($-\Delta V$ Cut off Charging System)

(A) This system cuts-off the high-rate charge current by detecting the drop in voltage in the cell after voltage has reached its peak during charge (Fig. 24).

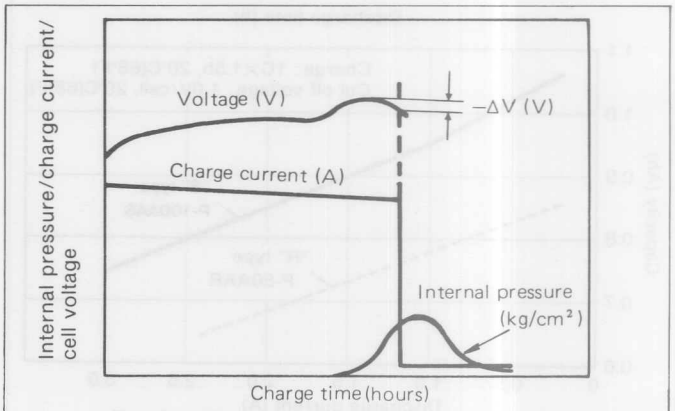


Fig. 24 Charging characteristics $-\Delta V$ cut off charging system.

The amount of this voltage drop ($-\Delta V$) is detected, and the charging current is dropped to C/10 or less (C/30 is minimum). The value of $-\Delta V$ is usually 10mV/cell at 20°C (68°F). The basic circuit is shown in Fig. 25. (When using this system it is suggested that you contact National for technical assistance.)

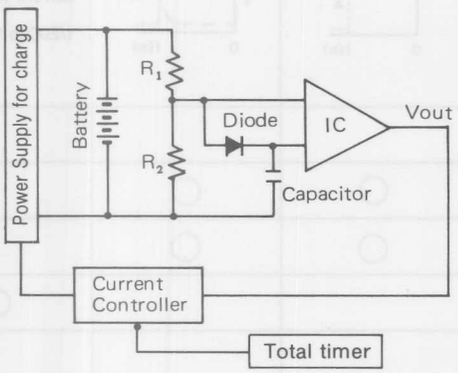


Fig. 25 Basic circuit: $-\Delta V$ cut off charging system

1.7.3.2. Temperature cut off charging system

(A) As shown in Fig. 26, charging at the C rate raises the cell temperature. The rise of the temperature to a predetermined level can be detected, and the charging current cut off or dropped to the C/10 ~ C/30 rate.

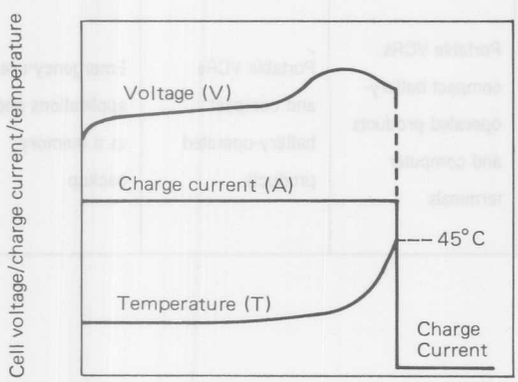


Fig. 26 Charging characteristics of temperature cut off charging system

(B) The temperature sensor is placed within the battery pack (Fig. 27), and in direct contact with the cells. The temperature sensor is usually set at 45°C.

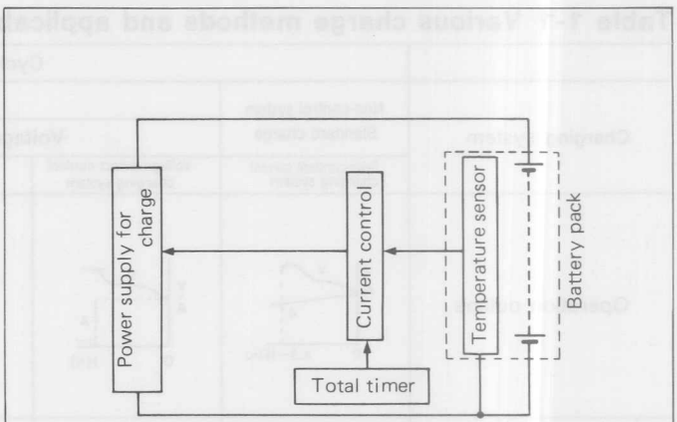


Fig. 27 Block diagram for temperature cut off rapid charger

1.7.3.3. Thermal protection

(A) It should be noted that for charging at the C rate, a thermal protector is provided in the pack (Fig. 28) and in contact with the cells, in order to protect against an accident due to charger malfunction. This thermal protector breaks the circuit if there is an abnormal increase in cell temperature, and protects against fire or deformation of the pack.

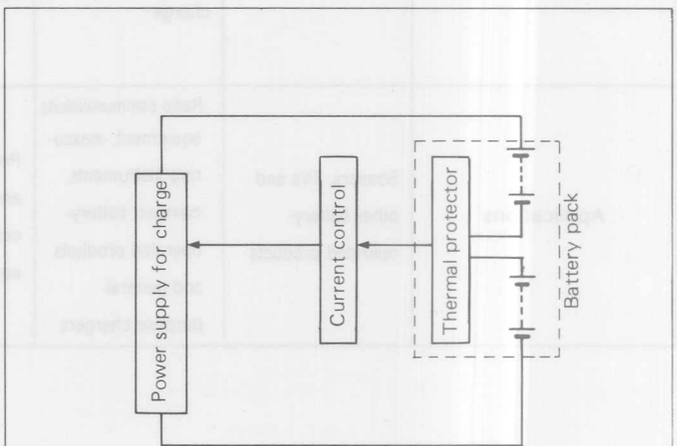
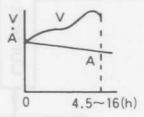
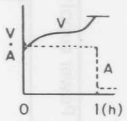
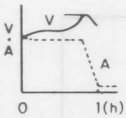
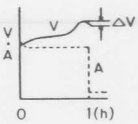
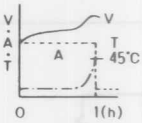


Fig. 28 Diagram for thermal protection

Note: For other types of charging systems, Please see Table 1-1.

Table 1-1 Various charge methods and applicable battery types (reference)

Charging system		Cycle (repeated) use					Standby use (Spare power supply)
		Non-control system Standard charge	Control system				
			Voltage detection system			Temperature detection system	Trickle charge system
		Semi-constant current charging system	Voltage detect control charging system	V taper control charging system	−Δ V cut off charging system	Temperature cut off chargihg system	
Operation outline							Semi-constant current charge at 1/20C to 1/30CmA
Battery type	Standard type	○	○	○			
	Rapid charge "R" type	○			○	○	
	Super high capacity & rapid charge "S" type	○			○	○	
	High temperature "H" type						○
	High capacity "E" type	○		○			
	High rate discharge & rapid charge "R/P" type	○			○	○	
	Memory backup "H" type						○
Features		Simple, inexpensive charge circuit	Longer cycle life but with a tendency for insufficient charge	Full charge capability for complete safety	Ideal charge system that ensures full charge capability	Overcharge at low temperatures and undercharge at high temperatures	Simple, inexpensive charge circuit
Applications		Shavers, TVs and other battery-operated products	Radio communications equipment, measuring instruments, compact battery-operated products and general-purpose chargers	Portable VCRs and radio communications equipment	Portable VCRs, compact battery-operated products and computer terminals	Portable VCRs and compact battery-operated products	Emergency-use applications and as a memory backup

1.8. General Recommendations for Use

National Ni-Cd cells do not require most of the cautions for handling and use that are necessary for most other rechargeable cells. The National Ni-Cd cell is a maintenance-free battery. **The following is a basic description of how to use the National Ni-Cd cell in order to obtain maximum performance and service life.** Because the range of applications for the National Ni-Cd cell is extremely wide, **please contact us if the general methods described here must be exceeded.** Unless stated otherwise, the values given are for the standard type cell. For other types, please refer to the individual data sheets.

1.8.1. Incoming Inspection

(A) National Ni-Cd cells are generally shipped in the charged condition, but can upon request, be shipped in the discharged condition. Because a certain amount of self-discharge will occur during shipment, storage and other stages of the distribution process, cell voltage as received is lower than the voltage seen after charging. If the voltage is 1.20V/cell or higher, it is normal, for cells shipped charged.

(B) There are instances where, for special reasons, cells are shipped in the discharged condition. The voltage in such instances may fluctuate depending upon the degree of the discharge. These cells are normal if the voltage as received is 1.0V/cell, for cells shipped discharged.

(C) It is recommended, when a shipment is received, that a test is made to determine whether the open circuit voltage of the cells is in the range just specified.

(D) If a capacity test is to be made, first partially discharge the cell from the charged condition, and then charge for 15 hours at C/10 at room temperature. Capacity is checked by discharging at C/5 to 1.0V/cell. The cell is normal if the specified capacity is achieved within 1 ~ 3 charge/discharge cycles.

Note: For cells received in the discharged condition, begin with charging. [Test temperature; 20 ± 5°C (59 ~ 77°F)]

1.8.2. Temperature Conditions

1.8.2.1. Charge

Charging should be conducted as previously described in "Charging Methods" (Paragraph 1.7.) Consult with National regarding any other charging methods.

(A) **Charging temperatures range are:**

- **Standard charge: 0°~45°C (32°~113°F)**
- **C/3 quick charge: 10°~45°C (50°~113°F)**
- **Trickle (float) charge: 0°~65°C (32°~149°F)**
- **"R/P" and "R" type Rapid charge (−ΔV method): 10°~45°C (50°~113°F)**
- **Temperature sensing system: 10°~40°C (50°~104°F)**

Charging conducted at temperatures outside of these ranges, will have an adverse influence on cell life. In particular, when charging at low temperatures, hydrogen may be generated. If a sealed battery pack is used, for safety, ventilation holes should be provided.

(B) Even within the specified temperature range, cell life will be shortened if charging is always conducted at the low or high end of the temperature range. For longest life, it is recommended that charging be conducted at an average temperature of 20° ~ 30°C.

1.8.2.2. Discharge

Discharge temperature ranges are −20° to +65°C (−4° to +140°F). Please consult National regarding use beyond these temperature conditions, or for discharge currents beyond those specified in data sheets. Because service life will be decreased by repeated discharges at extreme temperature, discharges between 20° and 30°C are recommended.

1.8.2.3. Storage

(A) National cells can withstand very long storage time under typical conditions at a storage temperature range of −20° to +45°C (−4° ~ 113°F). If the cell must provide full capacity after storage, completely charge the cell before use. In addition, after prolonged storage, completely normal capacity can be returned within 1 ~ 3 charge/discharge cycles.

(B) It is recommended that the "R" type cell be stored in the discharged condition. It can be quickly recharged back to normal capacity.

(C) Batteries should not be stored continuously in a high temperature environment. Cell characteristics can best be retained if storage is maintaind at an average temperature of 30°C or less.

Note: Please consult National for use in temperature beyond these conditions.

1.8.3. Cell Reversal

In general, cell reversal should be avoided. If several cells are to be connected in series, it is suggested that they have similar ("matched") capacities. National automatically matches cells when making battery pack assemblies, and at no extra charge. Where discharge currents will be high, or prolonged, and cell reversal can be anticipated, a low-voltage cut-off is suggested. When using a low voltage cut off, a cut off of 1.0 ~ 1.15V/cell is recommended.

1.8.4. Short-circuit Protection

Because the internal resistance of National Ni-Cd cells is extremely small, a short-circuit will produce very high current. A current equivalent to 30 ~ 50 times the rated capacity will flow, resulting in heat

generation and damage to the cell's insulator and surrounding parts. Therefore, it is important to make sure that a short-circuit does not occur when and after cells are installed in equipment. The use of a fuse or a resettable thermostat in the battery circuit is recommended.

1.8.5. Packaging and Terminals

(A) National offers preassembled battery pack, or cells equipped with solder tabs. (See Section 4). If you do your own assemblies, **do not solder directly to the cell. Use solder tabs.**

(B) Single cells should be insulated. It is recommended that packs have an outer plastic cover or case for convenience in handling or mounting.

(C) As protection in the unlikely event that gas might be generated, batteries should not be placed in totally sealed equipment; air ventilation holes should be provided.

1.8.6. Severe Use Applications

Temperature, charging, discharging and storage have been discussed, but each of these is related to time. **The National Ni-Cd cell can be used even at 85°C, if only for a short time.** But, because life will obviously be shortened if use is continued under such extreme conditions, use at extreme temperature for longer period should be avoided.

Note: Please consult National for application beyond specified operating parameters.

1.9. Cell Failure

National cells are manufactured under strict quality control conditions. Every effort is exerted to assure that failures will not occur. However, because the cells are used in a wide range of applications and conditions, it is inevitable that some failures will occur.

There are two types of cell failure; reversible and permanent.

1.9.1. Reversible Failures

(A) In a typical Ni-Cd cell, either long term storage, or prolonged charging at high temperature will result in a lowered cell capacity. This is normally seen as a slight decrease in the average cell voltage. This loss of capacity can be removed by a full charge for stored cells, or 1 ~ 3 charge/discharge cycles for cells that have been on long term trickle charge.

(B) The so-called "Memory Effect" is virtually non-existent in National Ni-Cd cells, and presents almost no problem or incovenience to the user in typical use.

1.9.2. Permanent Failure

(A) Failures due to aging occur when there are very large numbers of charge/discharge cycles, and particularly where the charge or discharge takes place beyond specified operating ranges.

(B) Failures also will occur after storage for several years at continuous high temperature, through deep cell reversal, or if a trickle charge is applied for an extended period (close to 7 ~ 10 years).

- **A cell is considered to have reached the end of its normal life when it fails to yield 80% of its original rated capacity.**

1.10. Care in Handling

(A) Battery Connection to Electric Equipment
- Direct soldering of lead wires to the cell can cause damage to the separator, safety vent, insulator or other parts, due to heat.
- Do not solder the lead wires directly to the battery.
- Spot weld the tab to the battery and solder the lead wire to the tab.

(B) Parallel Charging Connection
- Parallel charging can produce irregular charging currents, and battery performance can be lowered by short or excess charging.
- Avoid charging batteries in parallel.
- If batteries are discharged in parallel, use protective diodes between them to avoid back discharge from one battery into the other.

(C) Contact Terminals
- Use battery holders and other contact materials made of nickel or nickel-plated steel.
- Copper, zinc, chrome or aluminum contacts should be avoided, as they tend to be prone to corrosion.

(D) Battery Position
- Place the battery apart from any heat sources in the equipment.

- When placed near a heat source, the performance of the battery drops as its temperature is raised. (See para 1.8.2.)

(E) Use in Sealed Equipment
- Do not put the battery in a totally sealed case or equipment.
- To avoid the possible explosion of hydrogen which can occasionally be vented from a battery, cases should be ventilated.

(F) Disassembly
- Do not disassemble the battery.
- It contains electrolyte which can cause injury to clothing or skin.
- In the event that electrolyte gets on skin or in eyes, immediately flush with pure water and see a doctor.

(G) Handling
- Do not pull on battery lead wires or connector.
- Excess force on the leads or connector can damage the solder joints or other connections.

(H) Short-circuiting
- Do not short-circuit the battery.
- Short-circuiting the battery produces very high currents which can damage the battery or the equipment.

(I) Disposal in Fire
- Do not dispose of the battery in a fire or incinerator.
- Disposal in this manner can cause the battery to explode.

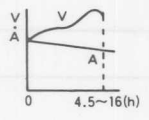
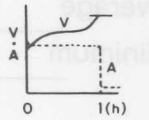
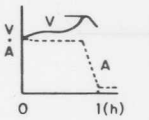
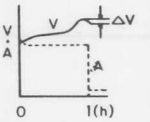
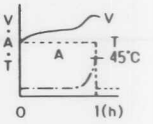
(J) Use of Mixed Cells and Types
- Do not use different types of batteries in the same battery assembly.
- The mixed use of dry cells, old and new cells, or cells of varying sizes in the same battery assembly can damage the battery or the equipment, due to varying electrical characteristics and capabilities.

2. Application and Selector Guide

2.1. Application Guide (Cell type vs. Application)

		Applications									
		Cyclic Use								Standby Use	
Cell Type	Features	Home Appliances	Communication and Telephone	Office Devices	Tools	Scientific Instruments and Medical Equipment	Photography and VCR	Toys and Hobby	Lights	Emergency Lights/ Alarms	Memory Backup
Standard	Wide range of applications, wide range of sizes. Charge : C/10 overnight Sub C or less : C/3~C/4, 4 to 6 hours	○	○	○		○	○	○	○		
Rapid Charge "R"	Controlled 1C for 1 ~ 1.5 hours	○	○	○		○	○	○	○		
High Temperature "H" For Emergency Backup	High charge/discharge efficiency for high-temperature trickle charge. Long life (Sizes: DH,CH,SCH,AAH,11AAH)									○	○
High Temperature "H" For Memory Backup	Ultra-long life for high-temperature trickle charge, high capacity for micro discharge currents. (Sizes: AAH,11AAH)										○
High Capacity "E"	Capacity is,1.2 to 1.3 times the standard cell. Charge: C/10 max.	○	○	○		○	○	○	○		
High Rate & Rapid Charge "R/P"	High rate discharge. 10~20C possible Rapid charge(1C)				○		○	○			
Super high Capacity & Rapid Charge "S"	Super high capacity (30% more capacity in same size) Rapid charge(1C)	○	○	○			○	○	○		

Table 1-1 Various charge methods and applicable battery types (reference)

Charging system		Cycle (repeated) use					Standby use (Spare power supply)
		Non-control system Standard charge	Control system				
			Voltage detection system			Temperature detection system	Trickle charge system
		Semi-constant current charging system	Voltage detect control charging system	V taper control charging system	−Δ V cut off charging system	Temperature cut off charging system	
Operation outline							Semi-constant current charge at 1/20C to 1/30CmA
Battery type	Standard type	○	○	○			
	Rapid charge "R" type	○			○	○	
	Super high capacity & rapid charge "S" type	○			○	○	
	High temperature "H" type						○
	High capacity "E" type	○		○			
	High rate discharge & rapid charge "R/P" type	○			○	○	
	Memory backup "H" type						○
Features		Simple, inexpensive charge circuit	Longer cycle life but with a tendency for insufficient charge	Full charge capability for complete safety	Ideal charge system that ensures full charge capability	Overcharge at low temperatures and undercharge at high temperatures	Simple, inexpensive charge circuit
Applications		Shavers, TVs and other battery-operated products	Radio communications equipment, measuring instruments, compact battery-operated products and general-purpose chargers	Portable VCRs and radio communications equipment	Portable VCRs, compact battery-operated products and computer terminals	Portable VCRs and compact battery-operated products	Emergency-use applications and as a memory backup

2.2. Battery Design Guide

This Battery Design Guide is provided to help you select the cells and battery configuration most suited to your application. We hope you find it useful.

For additional assistance, please contact National.

Application: _____

Voltage

Nominal _____

Minimum (discharge) _____

Maximum (charge) _____

Discharge conditions

- Current
  - Average _____
  - Peak _____
  - Minimum _____
- Time
  - Overall (Total) _____
  - At peak _____
- Temperature
  - Average _____
  - Maximum _____
  - Minimum _____

Charge conditions

- Time _____
- Method
  - Standard _____
  - Trickle _____
  - Quick (4~6H) _____
  - Rapid (1~1.5H) _____
- Temperature
  - Maximum _____
  - Minimum _____

Shelf life

- Period _____ Years
- Temperature
  - Maximum _____
  - Average _____
  - Minimum _____

Battery packaging

Heat shrink tube _____

Molded case _____

Other _____

Dimensions

Depth _____

Width _____

Height _____

Weight (desired) _____

Terminals

Solder tab _____

Lead wires _____ Length _____ Guage _____

Connectors _____ Type _____

Other _____

Battery requirements

Cell designation _____

Voltage _____

Capacity _____

No. of cells _____

Packing

Dimensions _____

Weight _____

Terminals (see above) _____

2.3. Cell Selector Guide (Discharge current – discharge time – type of battery)

(A) The data in Table 2-1 is based on the standard, "R", "P", and "E" types. See Table 2-2 for "H" types.
For more detail, see individual data sheets in section 4. For discharge rates faster than those shown, contact National

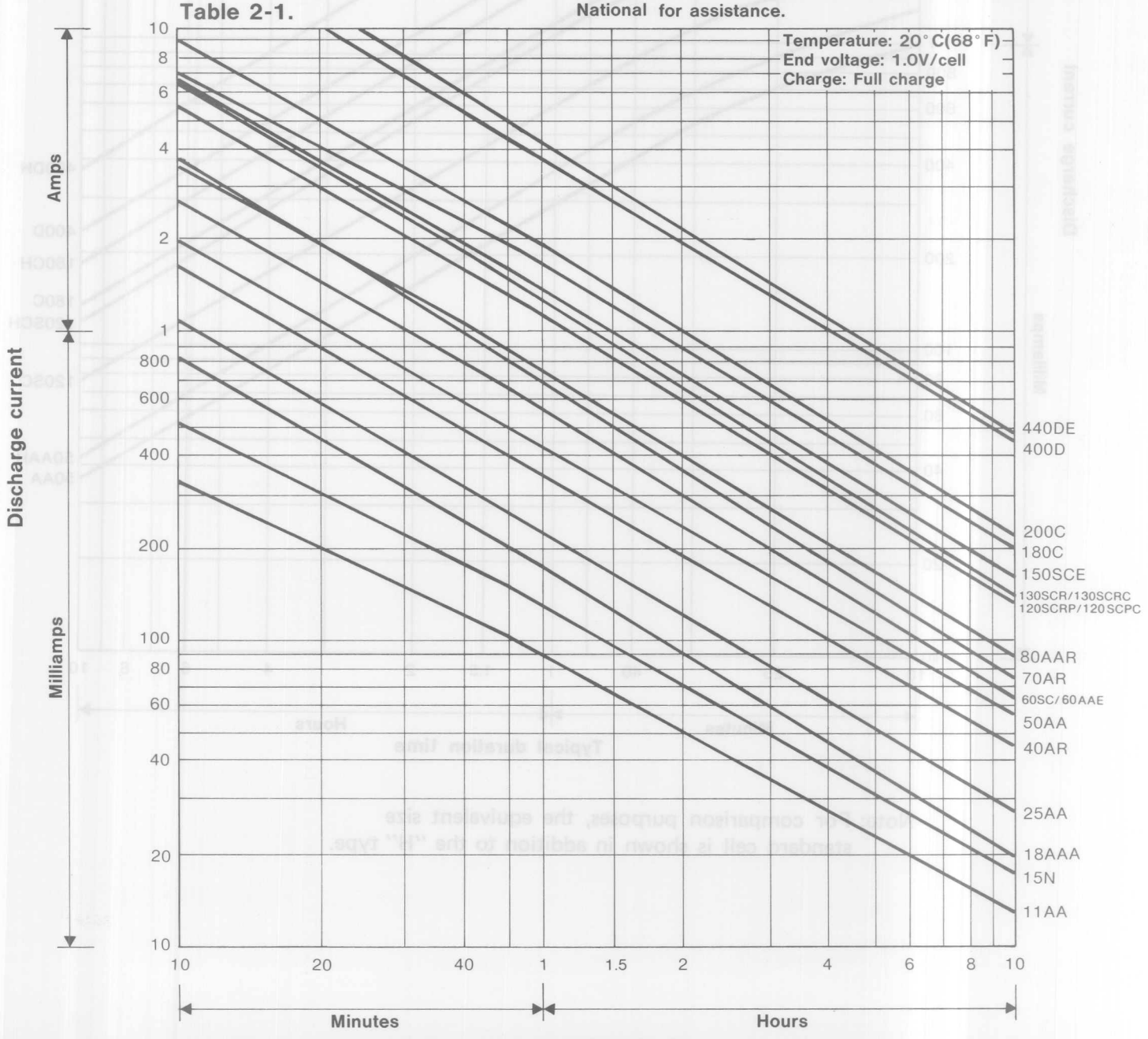
(B) Cell Selection:
- Determine desired run time and operating current.
- Use cell closest to the intersection of load and time on selector chart.

(C) Determination of cell model :
The cell is determined by the line nearest to point of required discharge time and discharge current.
Example: Discharge time; 1 hour
Discharge current; 1 Amp
from chart, 130SCR line is nearest to the circled point, so 130SCR is selected.

(D) Check that cells will fit into space available.

※For high rate applications, with discharges in under five minutes, please see the data sheets for the P-130SCR or P-120SCRP cells, or contact National for assistance.

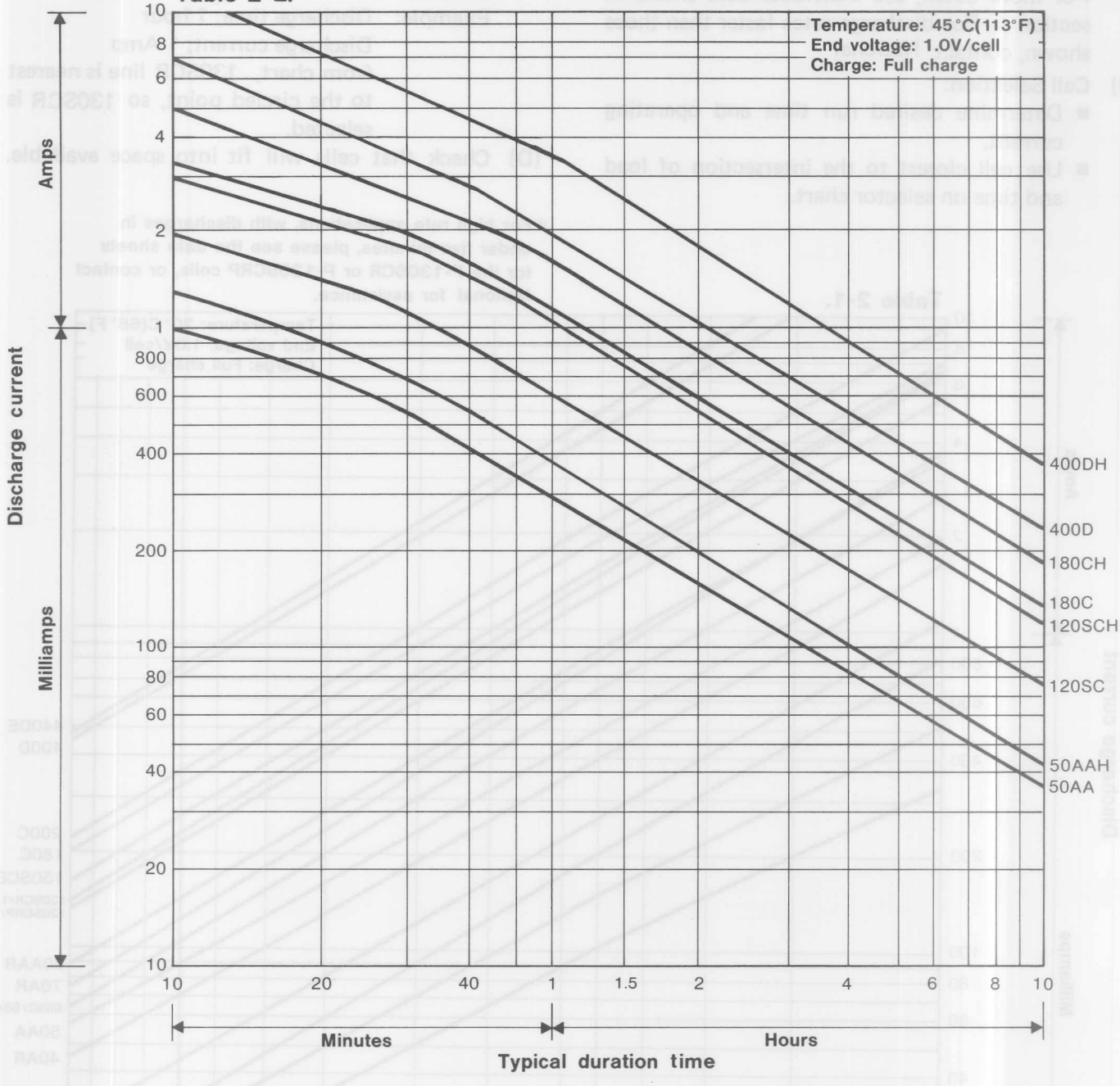
Table 2-1.



(E) High temperature "H" type selector chart is shown in Table 2-2.

Note: "H" type is usually used at high temperatures

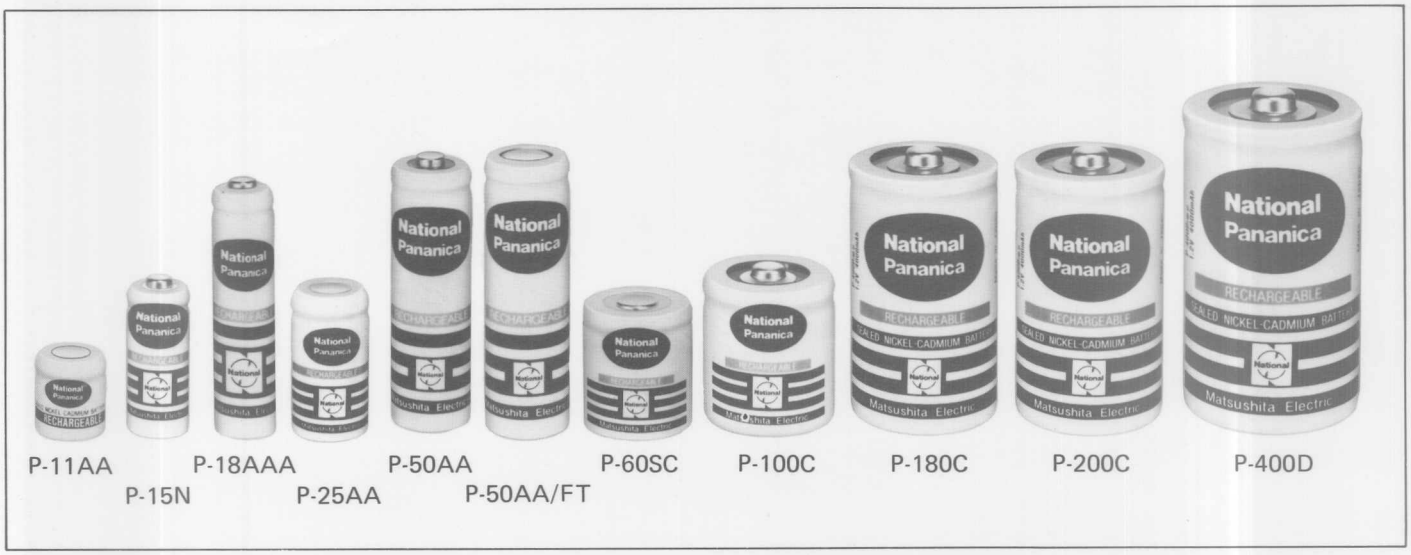
Table 2-2.



Note: For comparison purposes, the equivalent size standard cell is shown in addition to the "H" type.

3.Major Types: National Ni-Cd Batteries

Standard Type



■ Overview

The standard battery is a combination of high-grade positive and negative plates developed by National's own plate manufacturing process. It ensures a high level of electrical capacity and uniform quality among products of the same size. In addition, it features minimized internal resistance and superb discharge performance, displaying stable characteristics over a wide temperature range. Its sealed construction also improves safety and reliability with no need to add water, making it simple to handle. Furthermore, original special materials are employed for the insulation gasket, and liquid sealing guarantees reliable use on PC boards. The standard battery is available in a wide variety of models and sizes, meeting a broad range of applications.

■ Specifications

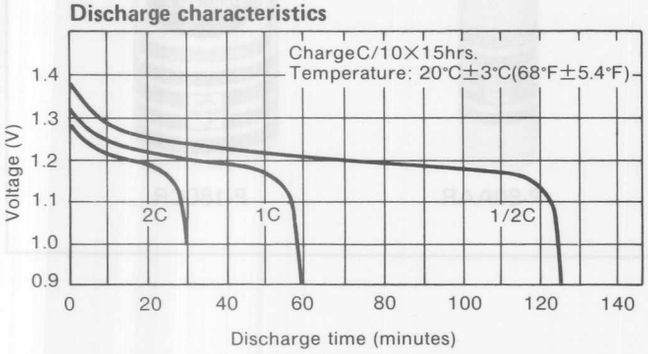
Model No.	Nominal voltage (V)	Nominal capacity C/5 (mAh)	Standard charge		Quick charge		Dimensions (with tube)		Approximate weight (g)
			Current (mA)	Hour (h)	Current (mA)	Hour (h)	Diameter inch(mm)	Height inch(mm)	
P-11AA	1.2	110	11	15	27.5	6	0.55±0.02(14.0±0.5)	0.65±0.02(16.5±0.5)	6.7
P-15N	1.2	150	15	15	38	6	0.45±0.02(11.5±0.5)	1.16±0.02(29.5±0.5)	8
P-18AAA	1.2	180	18	15	45	6	0.39±0.02(10.0±0.5)	1.73±0.02(44.0±0.5)	10
P-25AA	1.2	250	25	15	75	5	0.55±0.02(14.0±0.5)	1.09±0.02(27.7±0.5)	12
P-50AA	1.2	500	50	15	150	5	0.55±0.02(14.0±0.5)	1.95±0.02(49.5±0.5)	22
P-50AA/FT	1.2	500	50	15	150	5	0.55±0.02(14.0±0.5)	1.88±0.02(47.8±0.5)	22
P-60SC	1.2	600	60	15	150	6	0.89±0.02(22.5±0.5)	1.02±0.02(26.0±0.5)	29
P-100C	1.2	1000	100	15	333	4.5	1.00±0.02(25.3±0.5)	1.20±0.02(30.5±0.5)	45
P-180C	1.2	1800	180	15	—	—	1.00±0.02(25.3±0.5)	1.94±0.02(49.3±0.5)	73
P-200C	1.2	2000	200	15	667	4.5	1.00±0.02(25.3±0.5)	1.94±0.02(49.3±0.5)	75
P-400D	1.2	4000	400	15	—	—	1.27±0.03(32.3±0.7)	2.36±0.04(59.9±1)	136

Note : Regarding SC type, please see P-130SCR/P-130SCRC in page 36,37. For bare cell, refer to page 75.

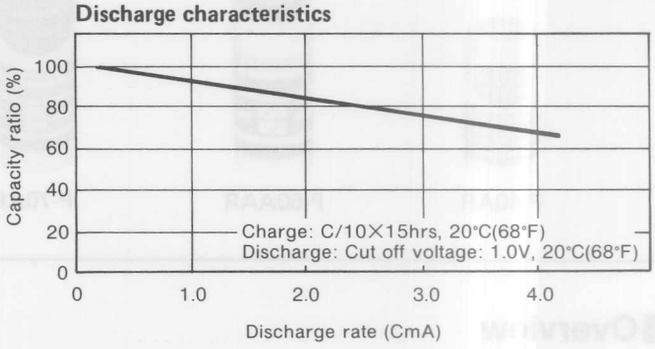
■Applications

- Shavers, tape recorders, portable VCRs, radios and hairdressing equipment
- Electronic calculators, ECRs, electronic printers, HHCs (hand-held computers), measuring instruments and pencil sharpeners
- Pocket pagers, cordless telephones, portable tranceivers and communioation equipment
- Cameras, electronic flashes, power tools, toys and lights
- Emergency radio broadcast equipment, fireproof shutters and alarms
- Memory backup and power backup systems

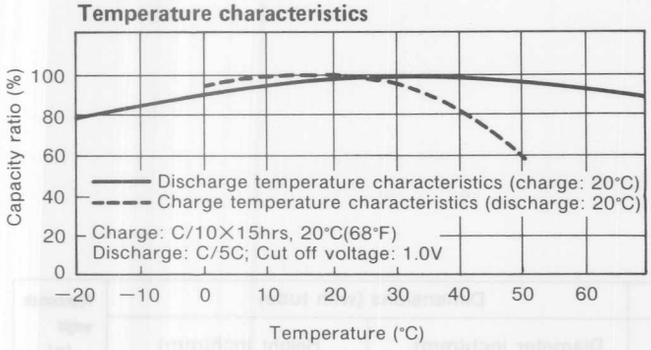
Discharge characteristics



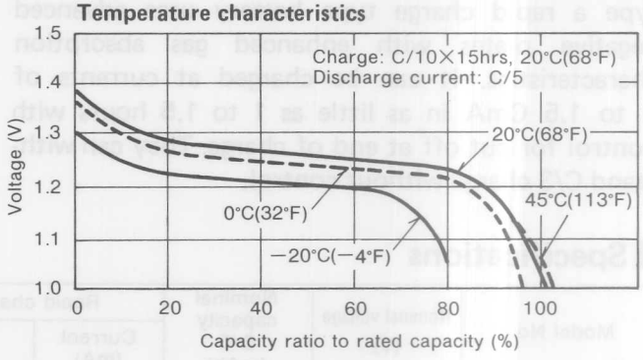
Discharge characteristics



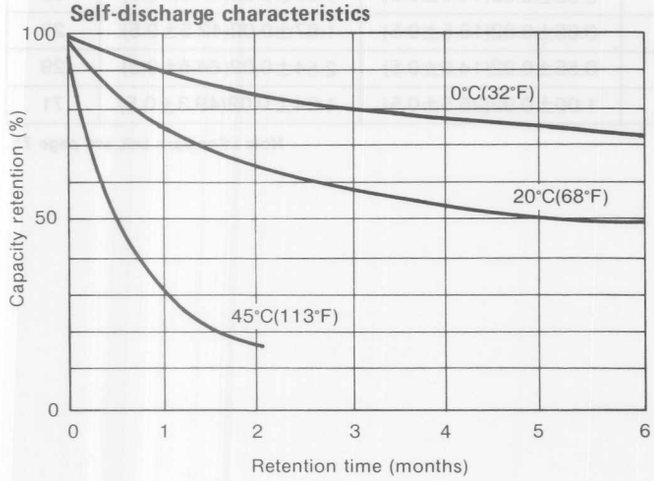
Temperature characteristics



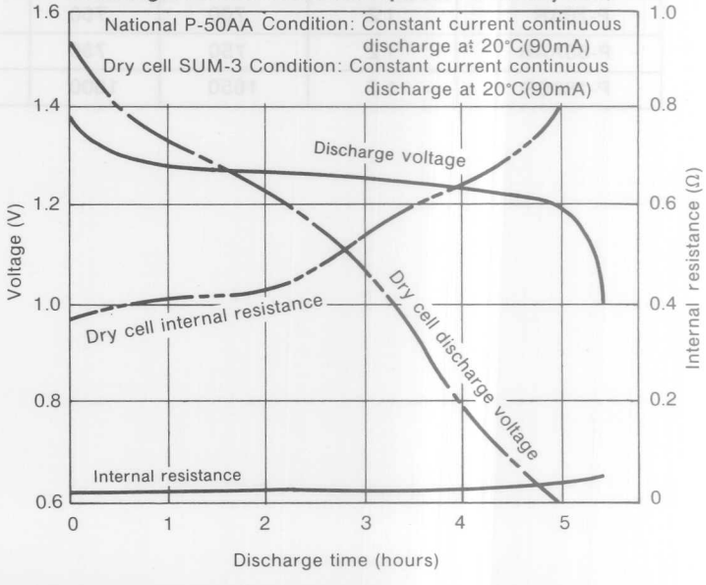
Temperature characteristics



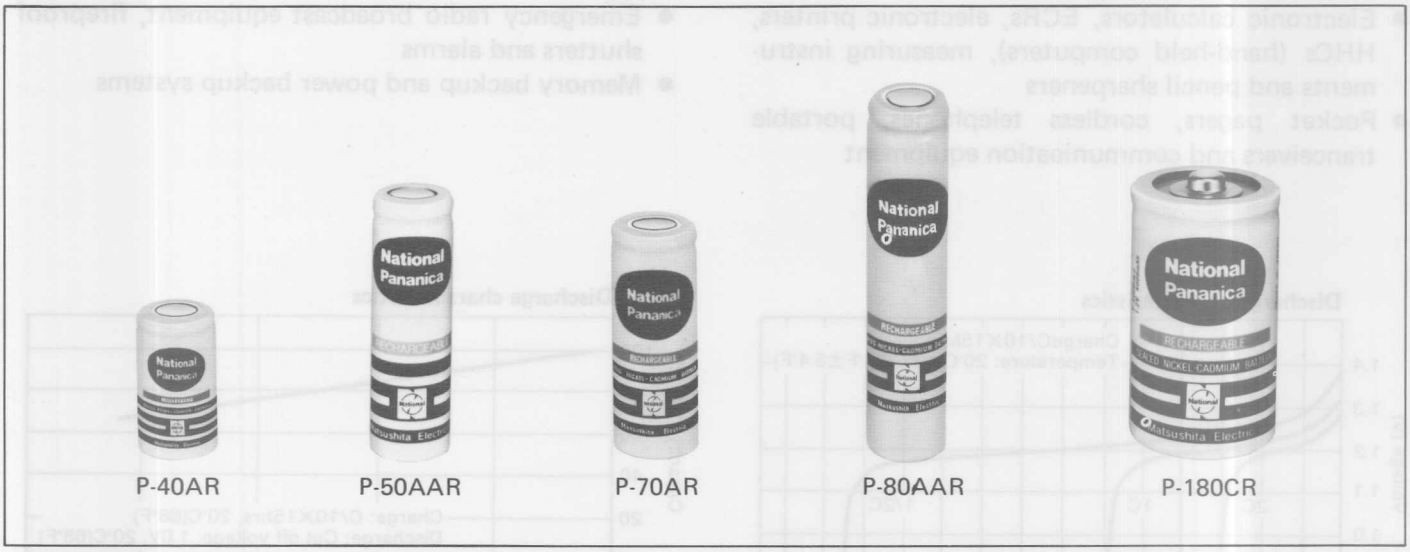
Self-discharge characteristics



Discharge characteristics (Comparison with dry cell)



Rapid charge "R" Type



P-40AR P-50AAR P-70AR P-80AAR P-180CR

■ Overview

Using National's total battery technology, the "R" type a rapid charge type battery uses advanced negative plates with enhanced gas absorption characteristics. It can be charged at currents of 1 to 1.5 CmA in as little as 1 to 1.5 hours with control for cut off at end of charge. They can withstand C/3 charge without control.

■ Specifications

Model No.	Nominal voltage (V)	Nominal capacity C/5 (mAh)	Rapid charge		Dimensions (with tube)		Approximate weight (g)
			Current (mA)	Hour (h)	Diameter inch(mm)	Height inch(mm)	
P-40AR	1.2	425	400	1.5	0.65±0.02(16.5±0.5)	1.10±0.02(28.0±0.5)	18
P-50AAR	1.2	500	500	1.5	0.55±0.02(14.0±0.5)	1.88±0.02(47.8±0.5)	22
P-70AR	1.2	700	700	1.5	0.65±0.02(16.5±0.5)	1.67±0.02(42.5±0.5)	27
P-80AAR	1.2	750	750	1.5	0.55±0.02(14.0±0.5)	2.54±0.02(64.5±0.5)	29
P-180CR	1.2	1650	1800	1.5	1.00±0.02(25.5±0.5)	1.94±0.02(49.3±0.5)	71

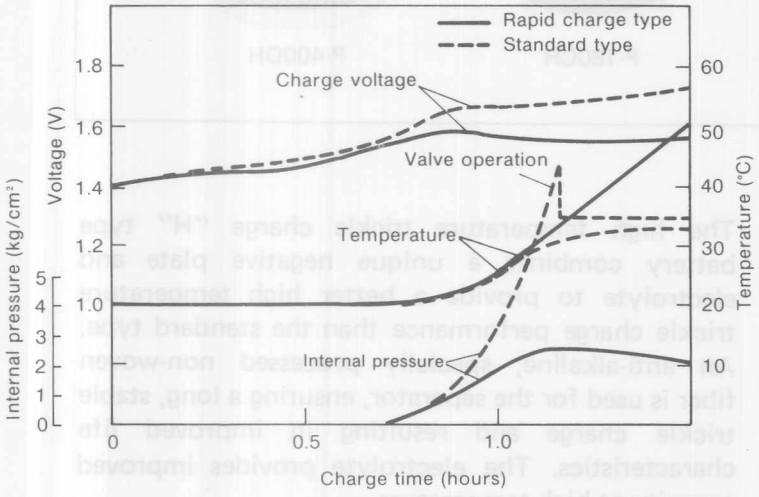
Note : For bare cell, see page 75.

Features

- **One-hour rapid-charging.**
  The rapid charge type battery can be charged within approximately an hour. This has been made possible by combining two systems: temperature detection and voltage control. The temperature detection system controls the charge current according to battery temperature. The voltage control system charges the battery with a comparatively high current until it is fully charged. These systems mean the battery capacity can be utilized 100%.

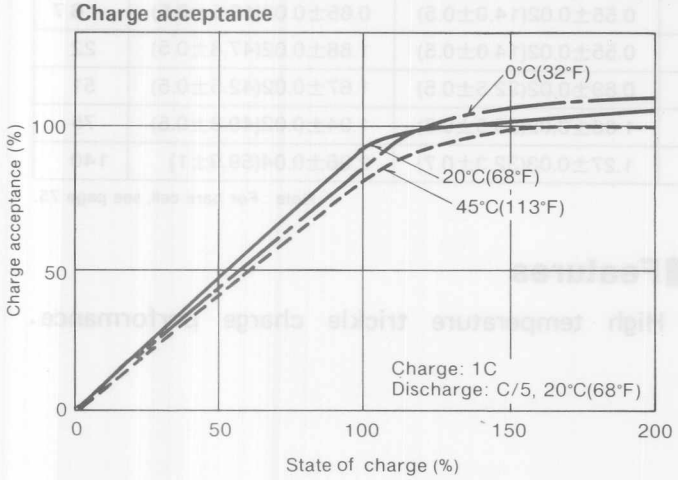
Rapid charge characteristics

Compared with the standard type



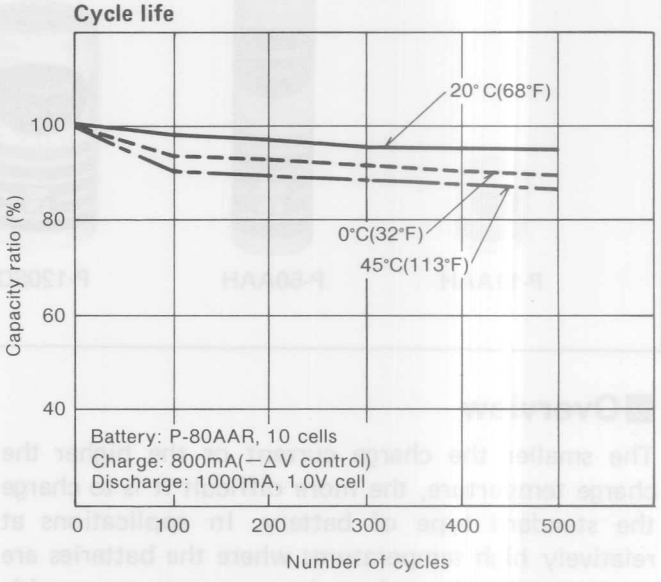
- **Excellent temperature characteristics**
  Charge acceptance remains almost unaffected by changes in temperature.

Charge acceptance

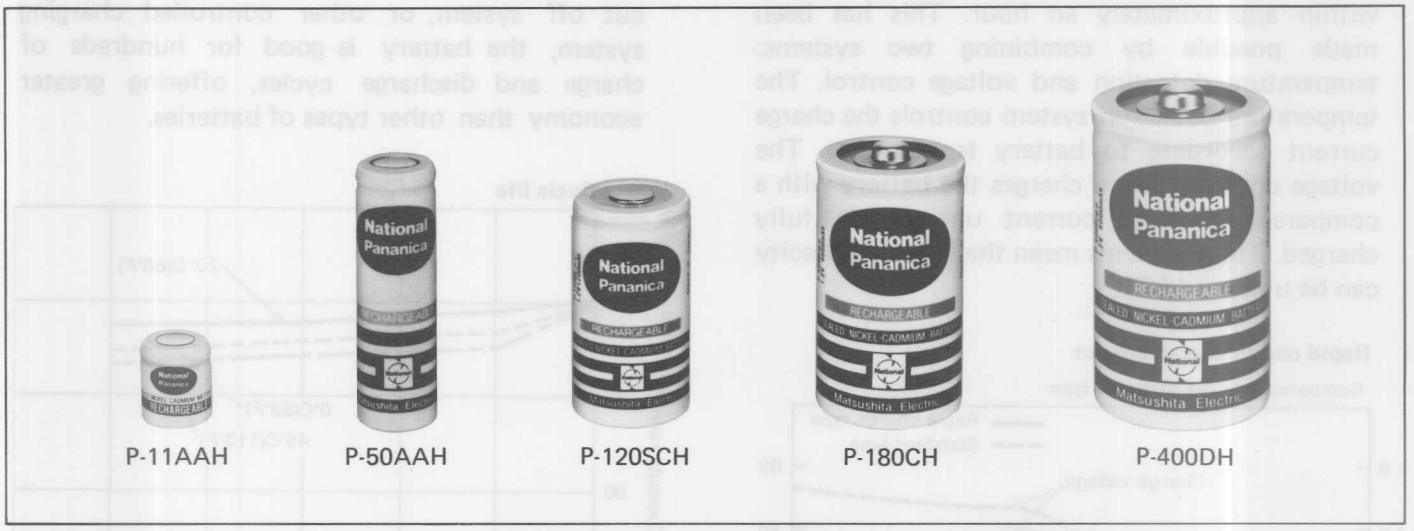


- **Long life**
  Combined with −ΔV charging system temperature cut off system, or other controlled charging system, the battery is good for hundreds of charge and discharge cycles, offering greater economy than other types of batteries.

Cycle life



High Temperature "H" Type



P-11AAH P-50AAH P-120SCH P-180CH P-400DH

■Overview

The smaller the charge current or the higher the charge temperture, the more difficult it is to charge the standard type of battery. In applications at relatively high temperatures where the batteries are continuously charged at low currents to provide power in the event of a power failure (e.g. guide lights, emergency lights, memory backup, etc.), excellent high temperature trickle charge performance is required.

The high temperature trickle charge "H" type battery combines a unique negative plate and electrolyte to provide a better high temperature trickle charge performance than the standard type. An anti-alkaline, specially processed non-woven fiber is used for the separator, ensuring a long, stable trickle charge and resulting in improved life characteristics. The electrolyte provides improved capacity at high temperature.

■Specifications

Model No.	Nominal voltage (V)	Nominal capacity C/5 (mAh)	Trickle charge		Dimensions (with tube)		Approximate weight (g)
			Current (mA)	Hour (h)	Diameter inch(mm)	Height inch(mm)	
P-11AAH	1.2	110	3.7	48	0.55±0.02(14.0±0.5)	0.65±0.02(16.5±0.5)	6.7
P-50AAH	1.2	500	17	48	0.55±0.02(14.0±0.5)	1.88±0.02(47.8±0.5)	22
P-120SCH	1.2	1200	40	48	0.89±0.02(22.5±0.5)	1.67±0.02(42.5±0.5)	51
P-180CH	1.2	1800	60	48	1.00±0.02(25.5±0.5)	1.94±0.02(49.3±0.5)	75
P-400DH	1.2	4000	133	48	1.27±0.03(32.3±0.7)	2.36±0.04(59.9±1)	140

Note : For bare cell, see page 75.

■Applications

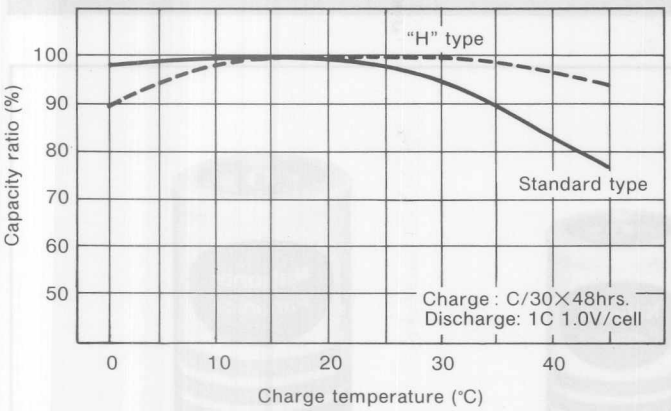
- Power supply for warning lights: Guide lights and emergency lights.
- Memory backup: For memory backup batteries, please see page 40.

■Features

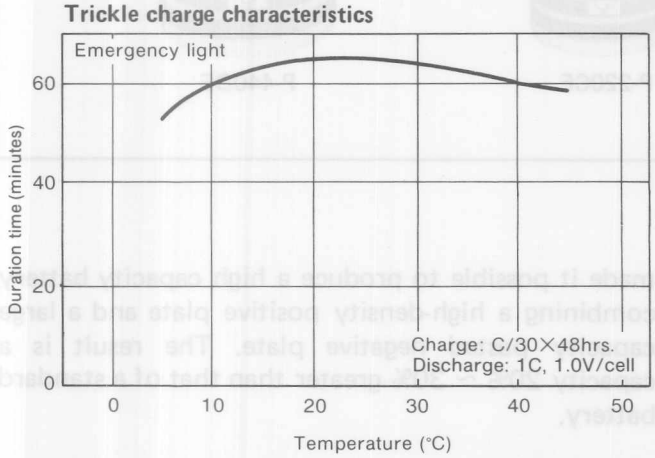
- High temperature trickle charge performance.

Trickle charge characteristics

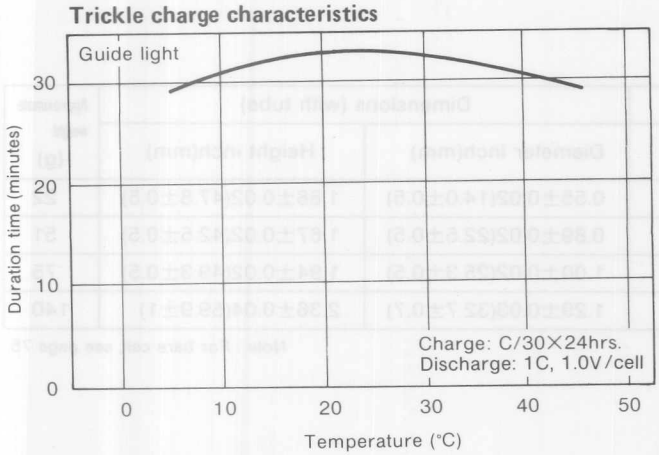
Compared with the standard type



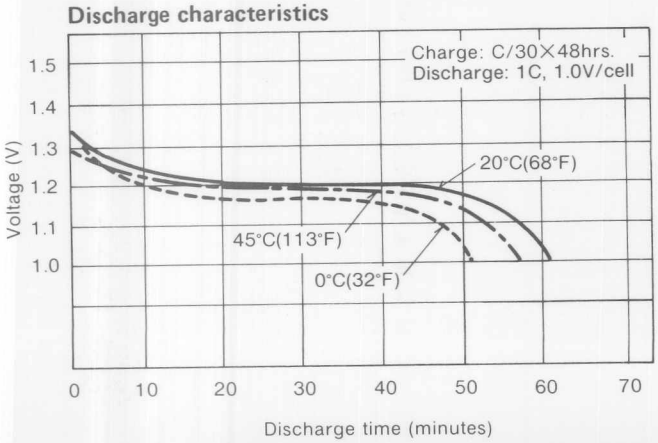
Trickle charge characteristics



Trickle charge characteristics



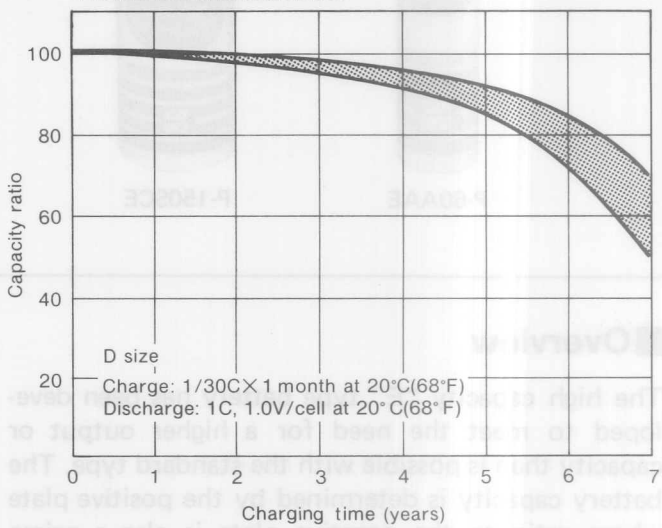
Discharge characteristics



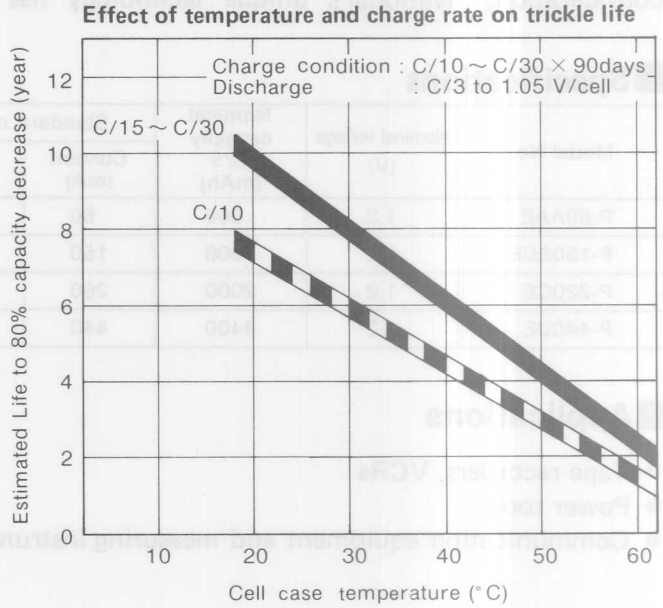
- **Long life and high reliability**

The high temperature trickle charge "H" type battery is not discharged except during power failure and its life is represented by the period of operation, not cycles. The battery life during trickle charge is affected by the ambient temperature, charge current, discharge frequency and the depth of discharge. Under normal operation, the life is expected to be 5 to 7 years, or even longer.

Trickle life characteristics



Effect of temperature and charge rate on trickle life



High Capacity "E" Type

P-60AAE

P-150SCE

P-220CE

P-440DE

■ Overview

The high capacity "E" type battery has been developed to meet the need for a higher output or capacity than is possible with the standard type. The battery capacity is determined by the positive plate whose ratio to the negative plate is also a prime consideration. National's unique technology has made it possible to produce a high capacity battery combining a high-density positive plate and a large capacity pasted negative plate. The result is a capacity 20% ~ 30% greater than that of a standard battery.

■ Specifications

Model No.	Nominal voltage (V)	Nominal capacity C/5 (mAh)	Standard charge		Dimensions (with tube)		Approximate weight (g)
			Current (mA)	Hour (h)	Diameter inch(mm)	Height inch(mm)	
P-60AAE	1.2	600	60	15	0.55±0.02(14.0±0.5)	1.88±0.02(47.8±0.5)	22
P-150SCE	1.2	1500	150	15	0.89±0.02(22.5±0.5)	1.67±0.02(42.5±0.5)	51
P-220CE	1.2	2000	200	15	1.00±0.02(25.3±0.5)	1.94±0.02(49.3±0.5)	75
P-440DE	1.2	4400	440	15	1.29±0.03(32.7±0.7)	2.36±0.04(59.9±1)	140

Note : For bare cell, see page 75.

■ Applications

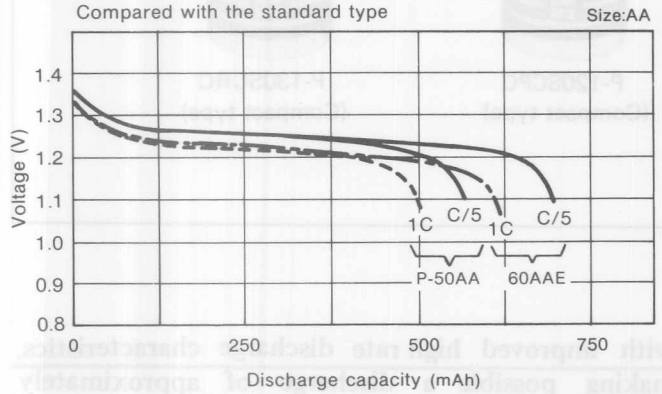
- Tape recorders, VCRs
- Power tools
- Communication equipment and measuring instruments

■ Features

- **20% ~ 30% increase in capacity**
  The "E" type has a capacity approximately 20% ~ 30% greater than the standard type. Compared to other batteries of the same size, the operating time is approximately 20% ~ 30% longer when the load current is constant. When the operating time is constant, the load current can be increased by approximately 20% ~ 30%. In addition, the battery size can be reduced by one rank.

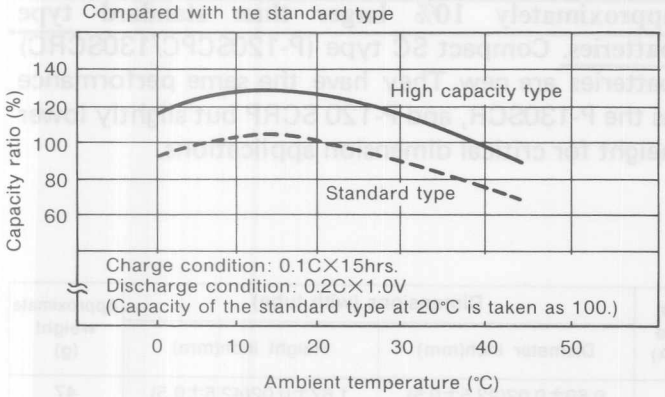
Discharge characteristics

Compared with the standard type



Temperature characteristics

Compared with the standard type



High Rate Discharge & Rapid Charge "R/P" Type.

P-120SCRP

P-130SCR

P-120SCPC
(Compact type)

P-130SCRC
(Compact type)

■Overview

This rapid charge, high rate discharge type has been developed through the integration of all National battery technology. It employs unique plates featuring unsurpassed gas absorption characteristics and a current-collecting system to provide charging in just one to one and a half hours. The internal resistance is also greatly reduced for improved voltage characteristics during high rate discharge at approximately 10 CmA.

The P-120SCRP in particular is extremely powerful with improved high rate discharge characteristics, making possible a discharge of approximately 25CmA. The P-130SCR with capability of high rate discharge (approx. 10CmA) boasts a capacity approximately 10% larger than standard type batteries. Compact SC type (P-120SCPC/130SCRC) batteries are new. They have the same performance as the P-130SCR, and P-120 SCRP but slightly lower height for critical dimension applications.

■Specifications

Model No.	Nominal voltage (V)	Nominal capacity C/5 (mAh)	Rapid charge		Maximum discharge current (A)	Dimensions (with tube)		Approximate weight (g)
			Current (mA)	Time (h)		Diameter inch(mm)	Height inch(mm)	
P-120SCRP	1.2	1200	1200	1.5	30A	0.89±0.02(22.5±0.5)	1.67±0.02(42.5±0.5)	47
P-130SCR	1.2	1300	1300	1.5	13A	0.89±0.02(22.5±0.5)	1.67±0.02(42.5±0.5)	47
Compact type								
P-120SCPC	1.2	1200	1200	1.5	30A	0.89±0.02(22.5±0.5)	1.634±0.02(41.5±0.5)	47
P-130SCRC	1.2	1300	1300	1.5	13A	0.89±0.02(22.5±0.5)	1.634±0.02(41.5±0.5)	47

Note : For bare cell, see page 75.

■Applications

Applications	130SCR/130SCRC	120SCRP/120SCPC
Electric tools (drills, screwdrivers and saws)	○	○
Toys, radio-controlled cars and radio-controlled airplanes	○	○
Cordless cleaners	○	
VCRs	○	
Other high rate discharge applications	○	○
Other general applications	○	

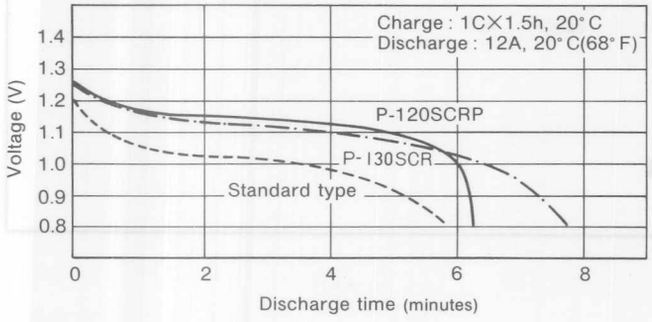
■Features

- **Excellent high-rate discharge characteristics**

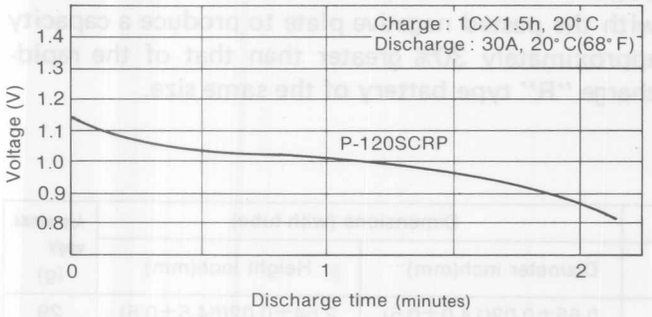
The new National cell displays 75% of the 1/5CmA capacity during discharge at 10CmA, approximately double the performance of standard type batteries. The P-130SCR provides capacity approximately 10% larger than that of the P-120SCRP.

The P-120SCRP is capable of very high rate discharge, approximately 25CmA.

High rate discharge characteristics (1)



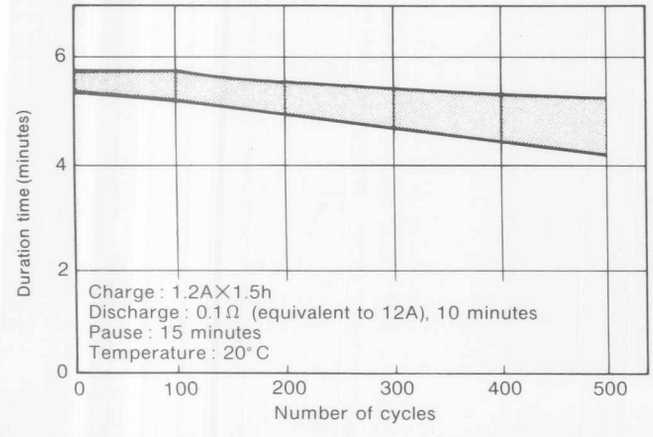
High rate discharge characteristics (2)



- **Long life**

When charged at 1CmA and discharged at 10CmA, the new National cell allows hundreds of charge/discharge cycles, providing stable voltage and run time over a long service life.

Cycle life characteristic

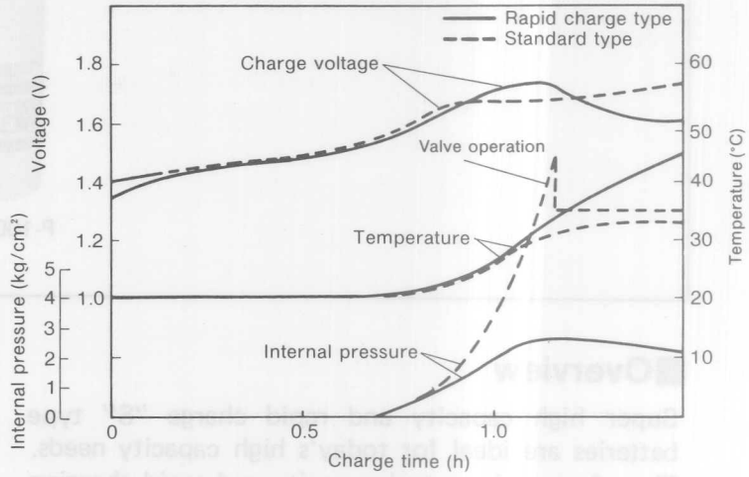


- **One-hour rapid charge**

The rapid-charge, high rate discharge "R/P" type combines a temperature detection system that controls the charge current according to battery temperatures with a voltage control system to allow full charge at a high current. As a result, it can be charged in a period as short as approximately one hour and still display a capacity of almost 100%.

Rapid charge characteristics

Comparison with the standard type



Super High Capacity and Rapid Charge "S" Type

P-100AAS

■ Overview

Super high capacity and rapid charge "S" type batteries are ideal for today's high capacity needs. They feature increased capacity and rapid charging within approximately one hour. The high-density positive base material of foam nickel is combined with the pasted negative plate to produce a capacity approximately 30% greater than that of the rapid-charge "R" type battery of the same size.

■ Specifications

Model No.	Nominal voltage (V)	Nominal capacity (C/5) (mAh)	Standard charge		Dimensions (with tube)		Approximate weight (g)
			Current (mA)	Hour (h)	Diameter inch(mm)	Height inch(mm)	
P-100AAS	1.2	1,000	1000	1.5	0.55±0.02(14.0±0.5)	2.54±0.02(64.5±0.5)	29

Note : For bare call, see page 75.

■ Applications

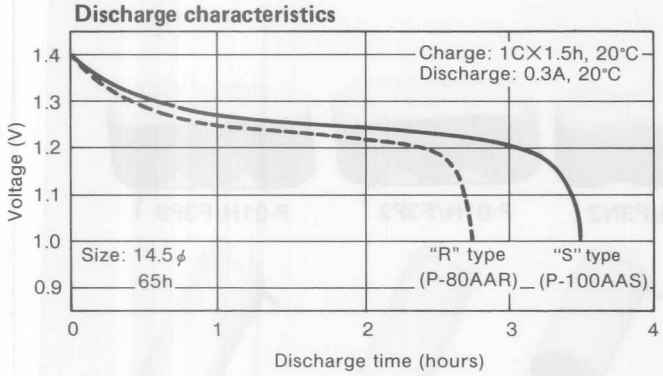
- Compact disc players, compact VCRs
- HHCs, communication equipment

■Features

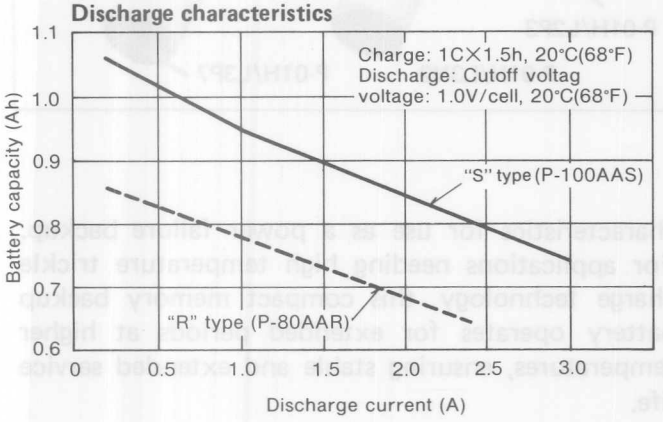
- **30% higher capacity**

The capacity is approximately 30% higher than that of the rapid-charge "R" type battery of the same size.

Discharge characteristics



Discharge characteristics

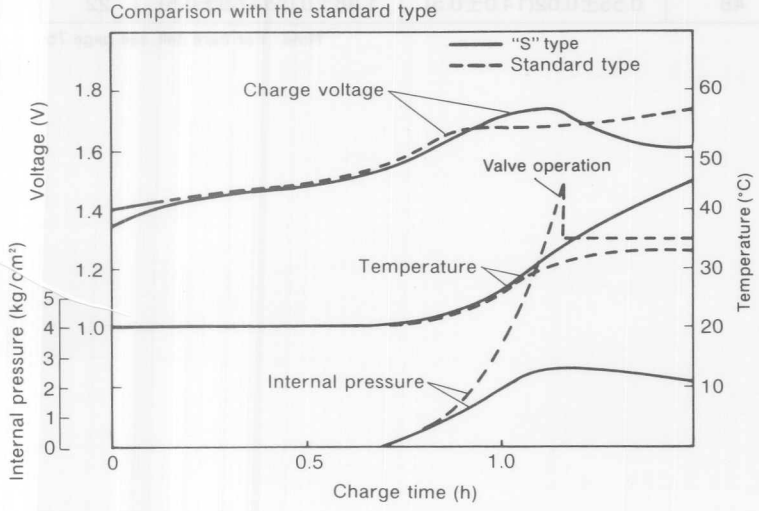


- **One-hour rapid charge**

Like the rapid charge"R"type, the"S"type battery can be charged rapidly. The use of −ΔV control circuit provides rapid one-hour charging.

Rapid charge characteristics

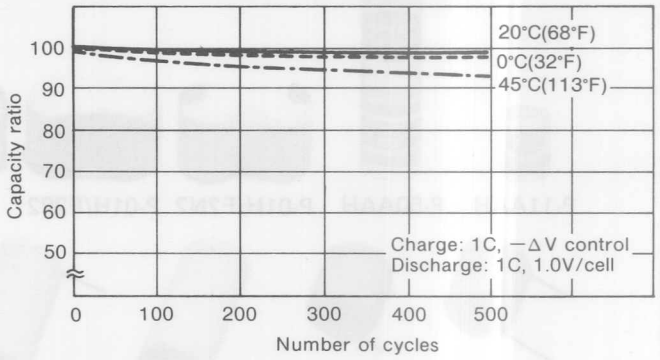
Comparison with the standard type



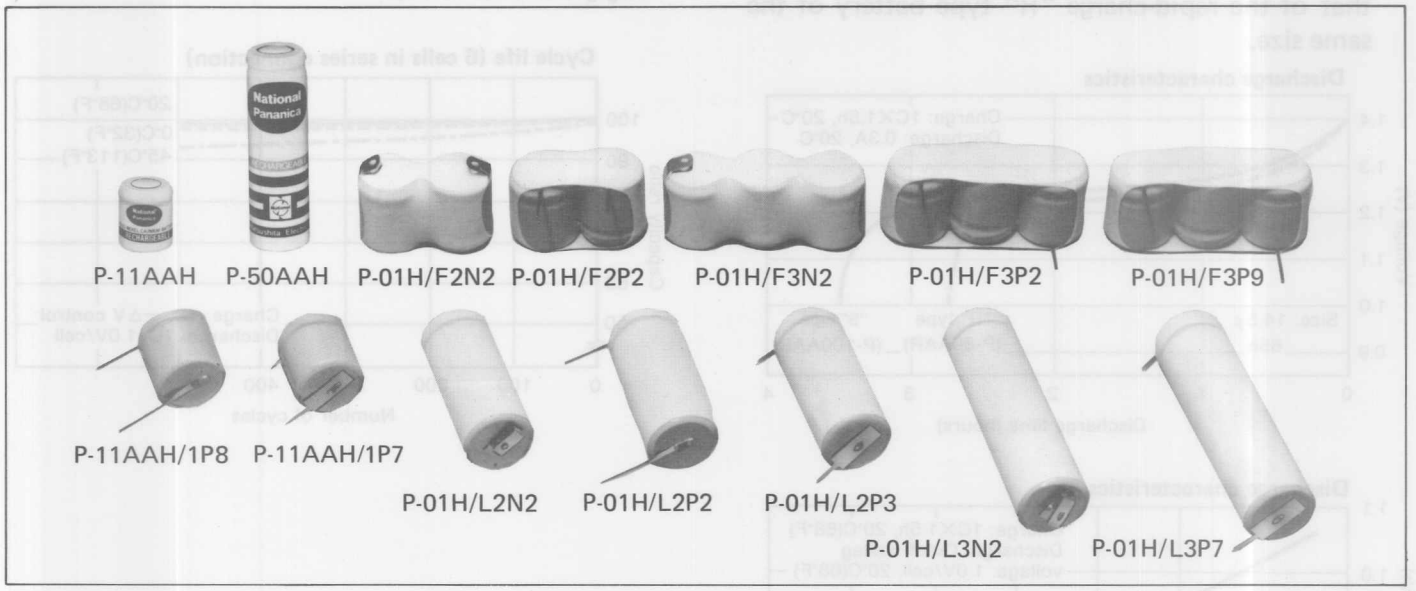
- **Long life**

Like the other types, this battery is capable of more than 500 charge and discharge cycles, offering greater economy.

Cycle life (6 cells in series connection)



Memory Backup Type



■ Overview

Rapid progress in electronics has brought about of equipment incorporating semiconductor memory devices. Many make use of volatile memory devices whose memories cannot be retained is there is a power failure cuts off the voltage. This has resulted in the demand for a compact battery featuring a long service life and high capacity retention characteristics for use as a power failure backup. For applications needing high temperature trickle charge technology, this compact memory backup battery operates for extended periods at higher temperatures, ensuring stable and extended service life.

■ Specifications (basic single cells)

Model No.	Nominal voltage (V)	Nominal capacity C/5 (mAh)	Standard charge		Dimensions (with tube)		Approximate weight (g)
			Current (mAh)	Hour (h)	Diameter inch(mm)	Height inch(mm)	
P-11AAH	1.2	110	3.7	48	0.55±0.02(14.0±0.5)	0.67±0.02(17.0±0.5)	6.7
P-50AAH	1.2	500	17.0	48	0.55±0.02(14.0±0.5)	1.88±0.02(47.8±0.5)	22

Note : For bare cell, see page 75.

■ Applications

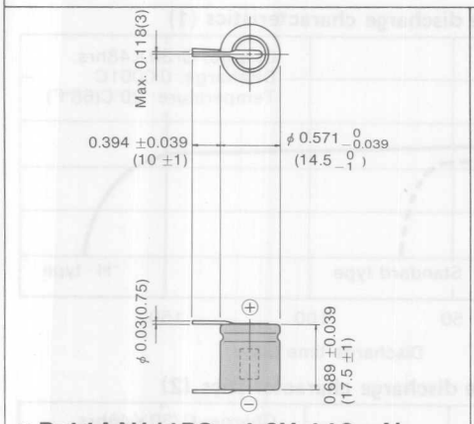
- Business equipment such as ECRs, consumer electronics such as TVs, VCRs, and stereos, as well as communication equipment, automobiles and various other electronic equipment which use semiconductors

PC mount type:
See Table 3-3 for available PC mount designs. These are shipped in discharged condition to permit wave-soldering.

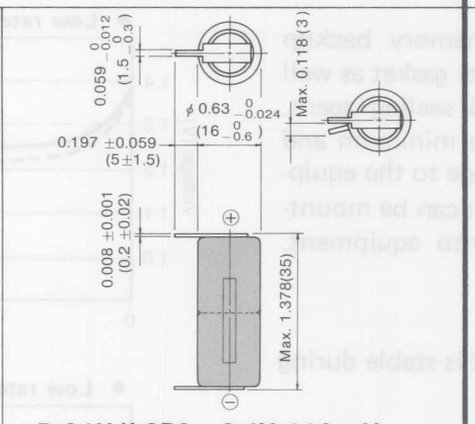
Table 3-3.

inch(mm)

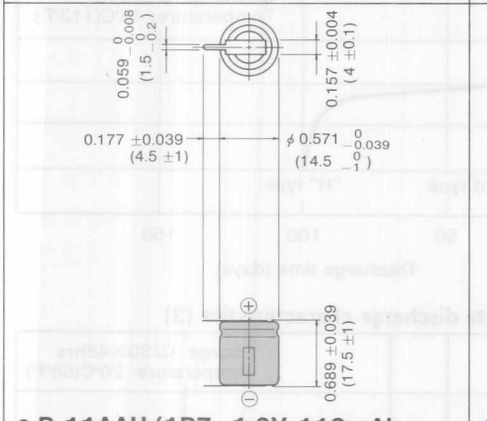
"L" Type



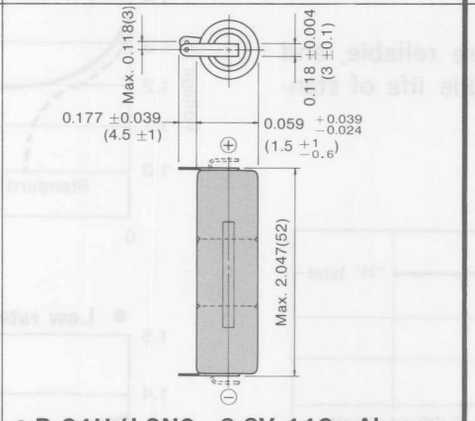
● P-11AAH/1P8 1.2V 110mAh



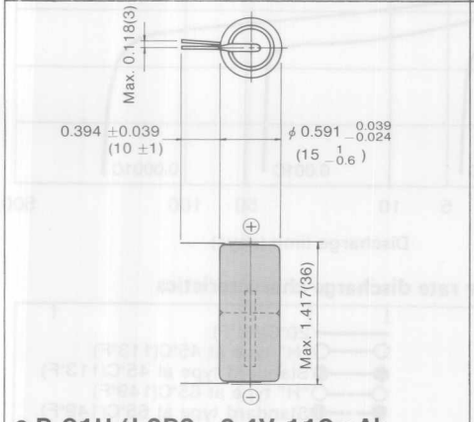
● P-01H/L2P3 2.4V 110mAh



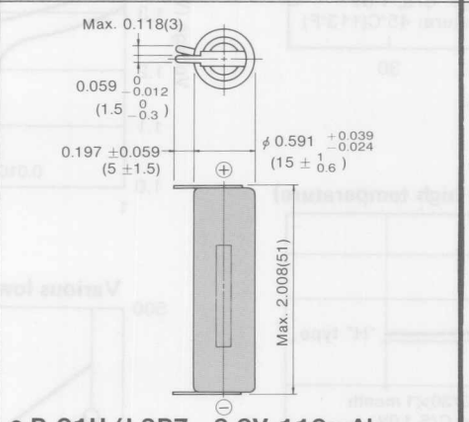
● P-11AAH/1P7 1.2V 110mAh



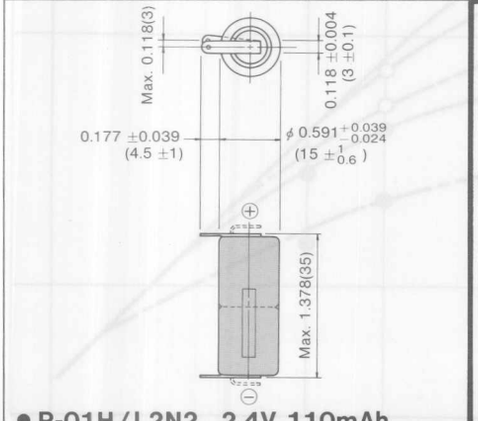
● P-01H/L3N2 3.6V 110mAh



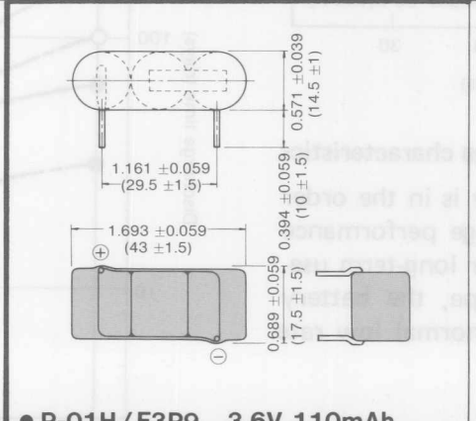
● P-01H/L2P2 2.4V 110mAh



● P-01H/L3P7 3.6V 110mAh

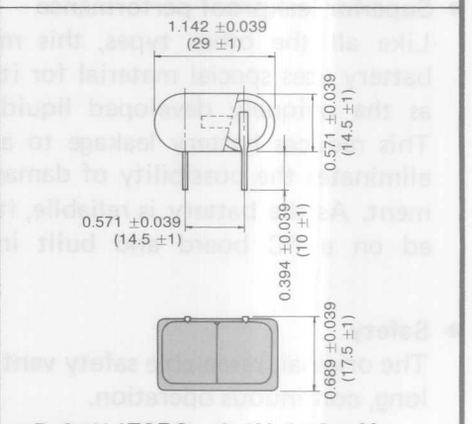


● P-01H/L2N2 2.4V 110mAh

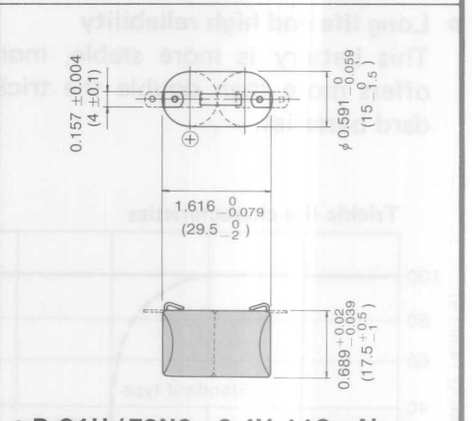


● P-01H/F3P9 3.6V 110mAh

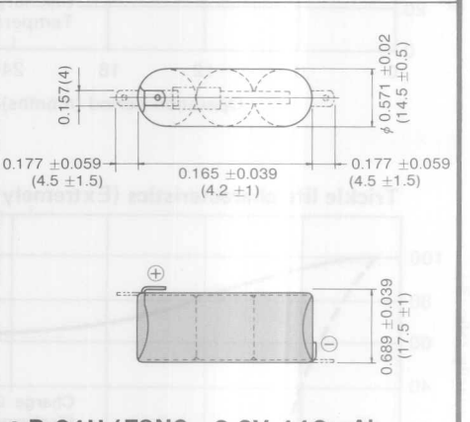
"F" Type



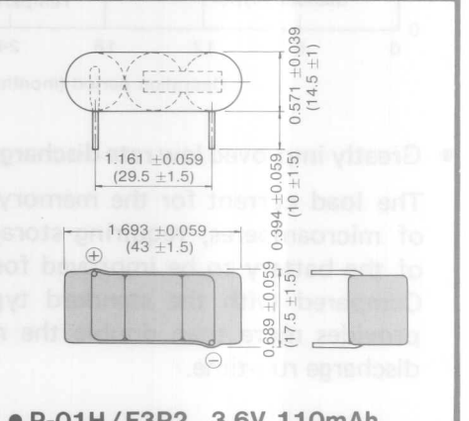
● P-01H/F2P2 2.4V 110mAh



● P-01H/F2N2 2.4V 110mAh



● P-01H/F3N2 3.6V 110mAh



● P-01H/F3P2 3.6V 110mAh

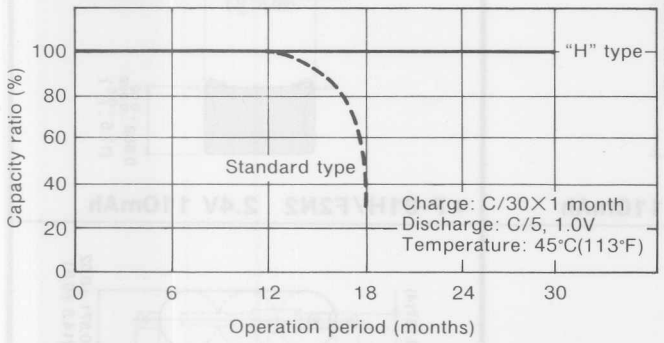
Features

- **Superior leakproof performance**
  Like all the other types, this memory backup battery uses special material for its gasket as well as the uniquely developed liquid sealing agent. This reduces battery leakage to a minimum and eliminates the possibility of damage to the equipment. As the battery is reliabile, it can be mounted on a PC board and built into equipment.

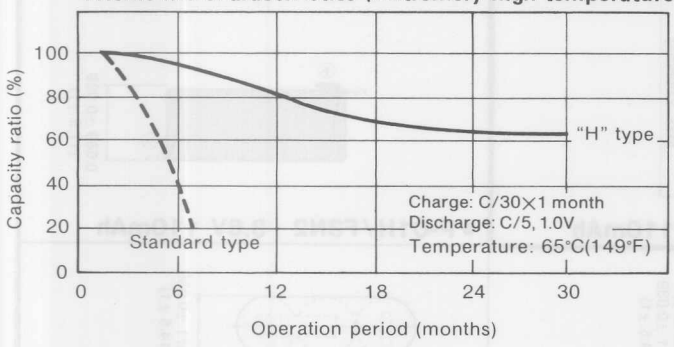
- **Safety**
  The original, resealable safety vent is stable during long, continuous operation.

- **Long life and high reliability**
  This battery is more stable, more reliable, and offers more than double the trickle life of standard batteries.

Trickle life characteristics

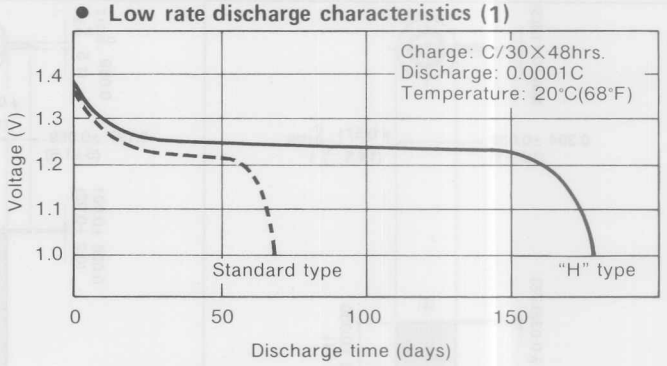


Trickle life characteristics (Extremely high temperature)

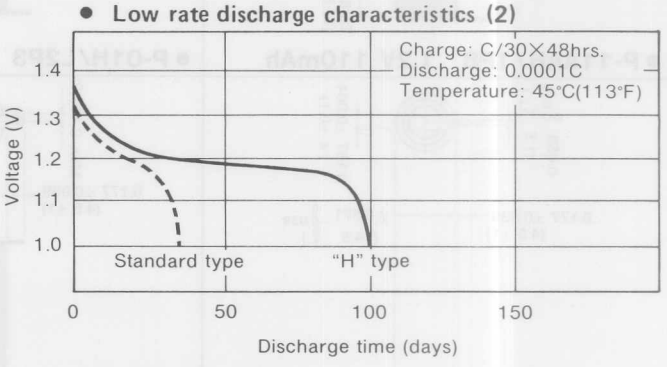


- **Greatly improved low rate discharge characteristics**
  The load current for the memory is in the order of microamperes, requiring storage performance of the battery to be improved for long-term use. Compared with the standard type, the battery provides more than double the normal low rate discharge run-time.

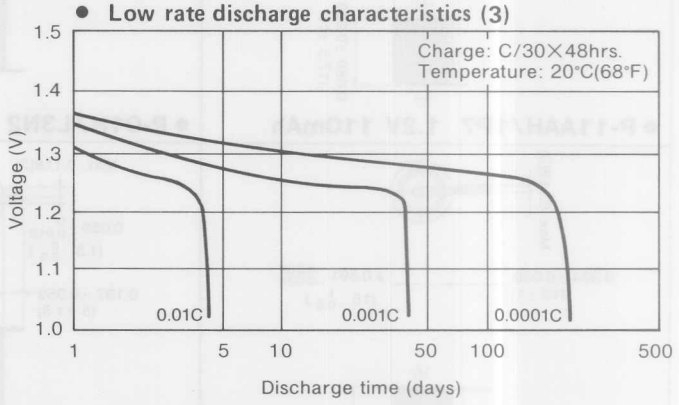
Low rate discharge characteristics (1)



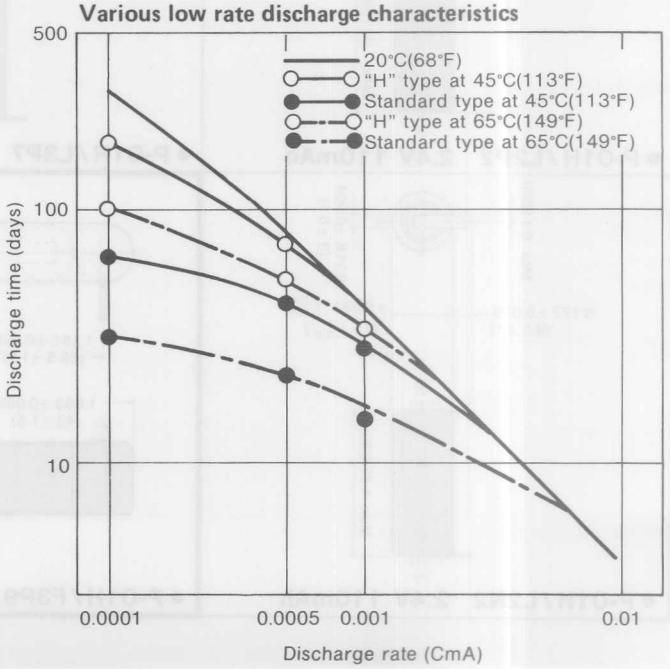
Low rate discharge characteristics (2)



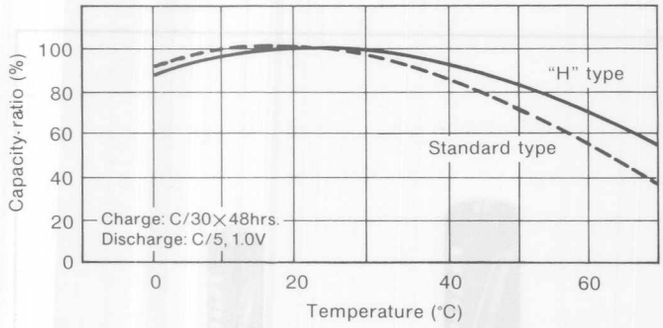
Low rate discharge characteristics (3)

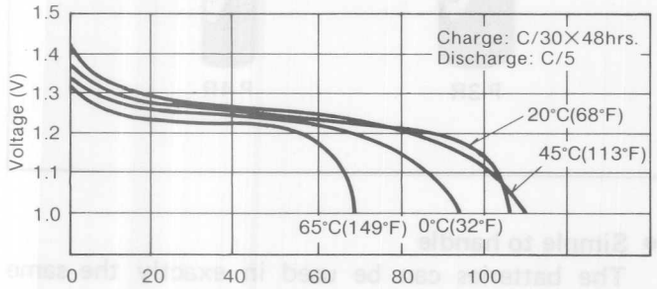


Various low rate discharge characteristics



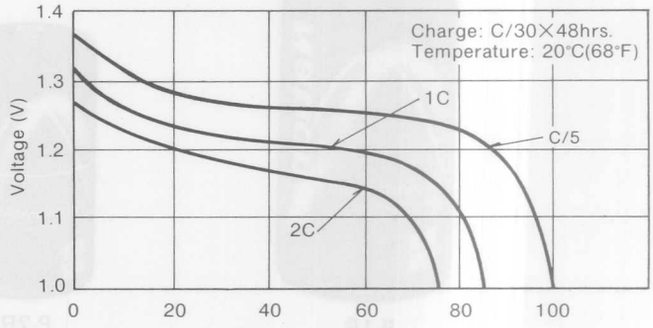
- **Trickle charge characteristics**





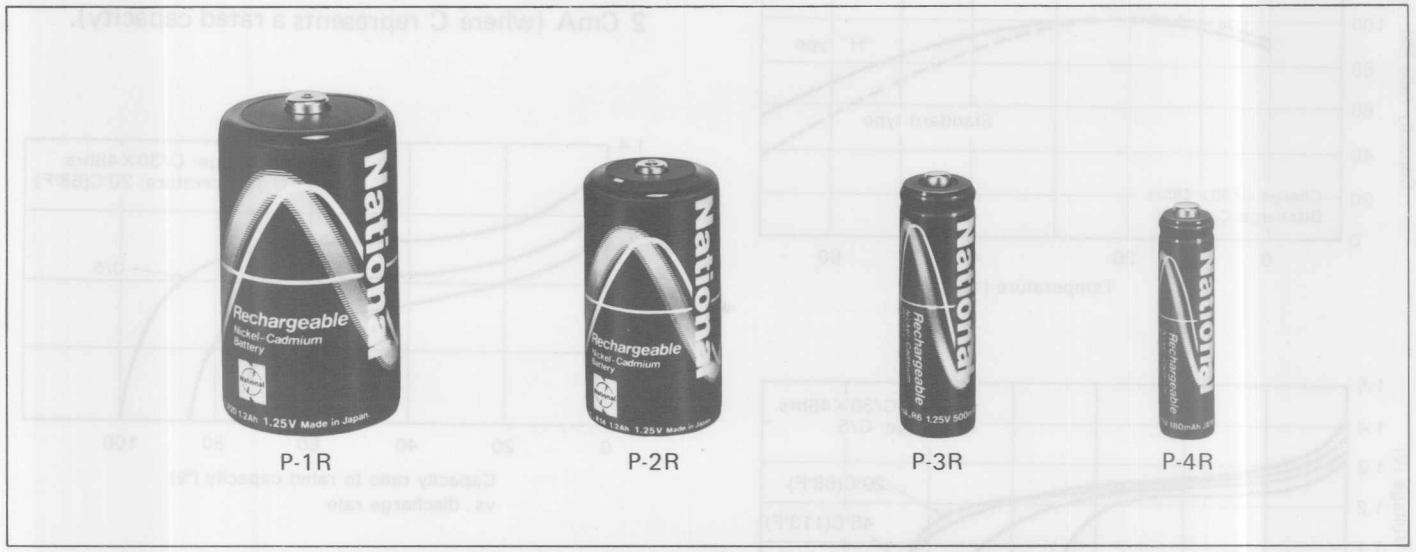
Capacity ratio to rated capacity (%)
vs. temperature

- **High rate discharge is also possible.**
  Basically, the memory backup battery remains the same as the standard type and can also be discharged at a high current of approximately 2 CmA (where C represents a rated capacity).



Capacity ratio to rated capacity (%)
vs. discharge rate

Consumer Type National Batteries



■Overview

Rechargeable batteries have also been in demand for equipment originally designed to operate on dry cells. To meet this demand, therefore, consumer type National Ni-Cd batteries are the same size as dry cells.

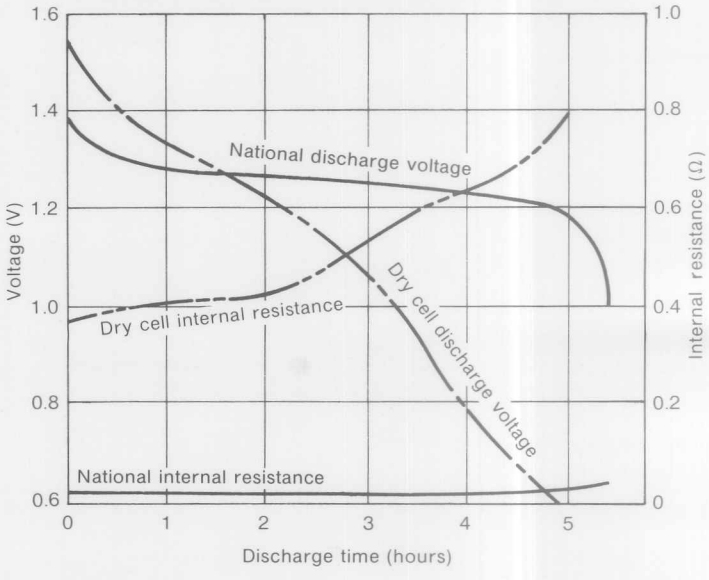
■Applications

- Radios, audio tape recorders, lighting equipment, electronic flashes, toys, electronic claculators, TVs, tranceivers, shavers, measuring instruments and electronic games

■Features

- **More economical than dry cells**
  Batteries of this type are capable of long-term charge and discharge cycles. In addition, charging them requires less electricity, making them more economical than dry cells.
- **High current discharge is possbile.**
  Minimized internal resistance facilitates high current discharge for battery capacity.
- **Simple to handle**
  The batteries can be used in exactly the same manner as dry cells, except for charging requirements.

○ National P-3R
Condition: Constant current continuous discharge at 20°C(90mA)
○ Dry cell R6 (KR15/51), AA
Condition: Constant current continuous discharge at 20°C(90mA)



■Specifications

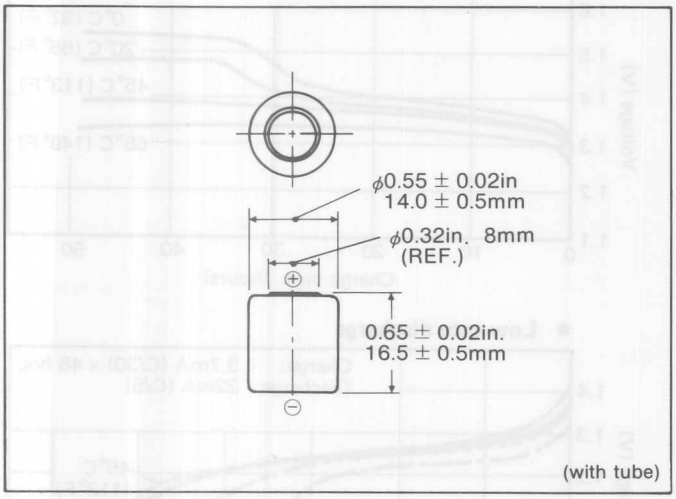
Model No.	Nominal voltage (V)	Nominal capacity C/5 (mAh)	Standard charge		Approximate weight (g)	Maximum dimensions (with tube)	
			Current (mA)	Hour (h)		Diameter inch(mm)	Height inch(mm)
P-1R	1.2	1200	120	15	70	1.346 (34.2)	2.421 (61.5)
P-2R	1.2	1200	120	15	60	1.031 (26.2)	1.969 (50.0)
P-3R	1.2	500	50	15	22	0.571 (14.5)	1.988 (50.5)
P-4R	1.2	180	18	15	10	0.413 (10.5)	1.752 (44.5)

4. Individual Data Sheets

P-11AA

Type: Standard
Size: 1/3 AA

110mAh



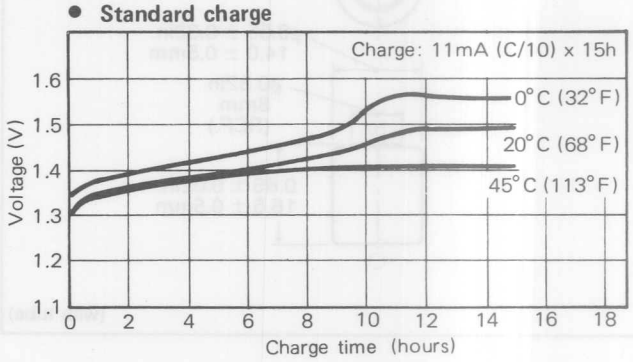
Specifications

Nominal voltage			1.2V		
Capacity (mAh)			C/10	C/5	1C
	Nominal		115	**110**	100
	Typical		125	120	110
Diameter			0.55 ± 0.02in. 14.0 ± 0.5mm		
Height			0.65 ± 0.02in. 16.5 ± 0.5mm		
Weight			0.24 ounces (6.7g)		
Internal impedance at 1000Hz.			60mΩ (After charge)		
Charge	**Standard**		11mA × 15h		
	Quick		27.5mA × 6h		
	Trickle	**Max.**	5.5mA		
		Min.	3.7mA		
Ambient temperature	**Charge**	**Standard**	0° to 45°C (32° to 113°F)		
		Quick	10° to 45°C (50° to 113°F)		
	Discharge		−20° to 65°C (−4° to 149°F)		
	Storage		−20° to 45°C (−4° to 113°F)		

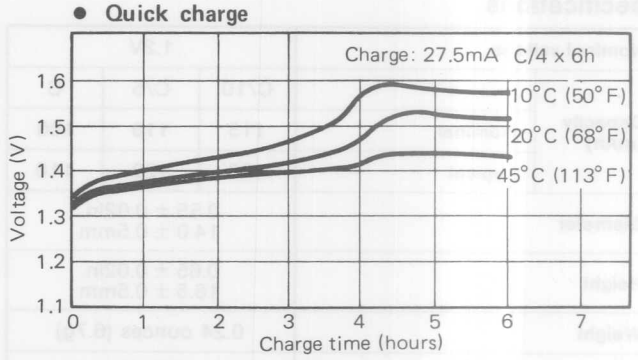
Note:
1. Nominal capacity, rated at C/5, 20°C
2. Other capacities are for reference.
3. See paragraph 1.6.2., for charging details.
4. Weight and internal impedance are for reference.
5. For bare cell, see page 75.

Typical characteristics

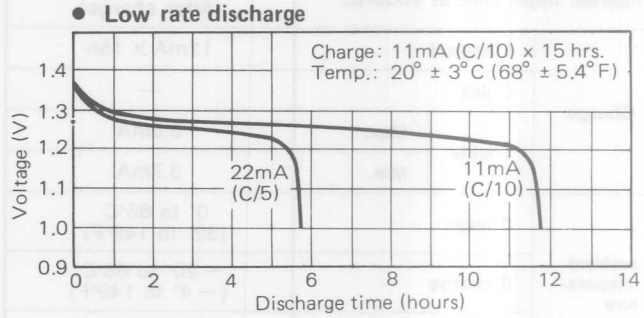
● **Standard charge**



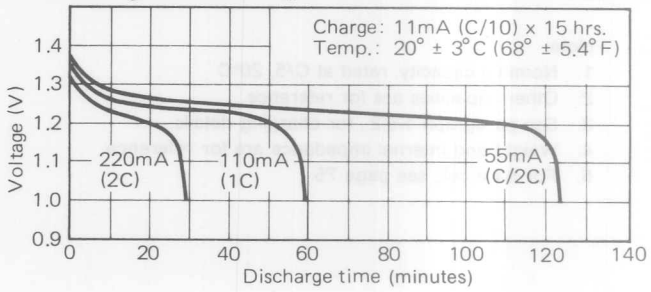
● **Quick charge**



● **Low rate discharge**



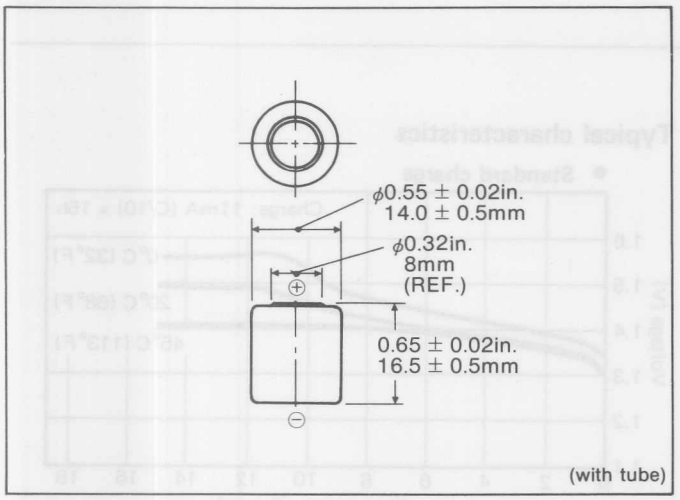
● **High rate discharge**



P-11AAH

Type: High Temp. "H"
Size: 1/3 AA

110mAh



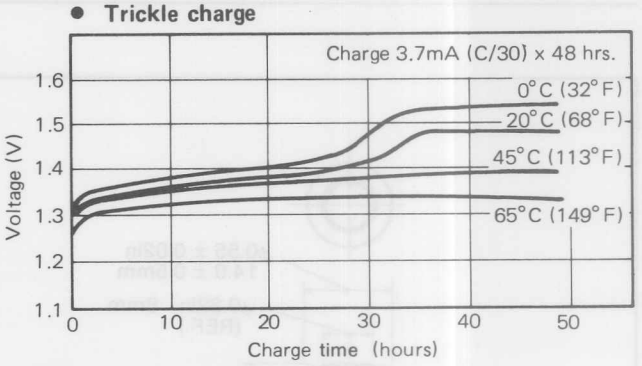
Specifications

Nominal voltage			1.2V		
Capacity (mAh)			C/10	C/5	C
	Nominal		115	**110**	100
	Typical		125	120	110
Diameter			0.55 ± 0.02in. 14.0 ± 0.5mm		
Height			0.65 ± 0.02in. 16.5 ± 0.5mm		
Weight			0.24 ounces (6.7g)		
Internal impedance at 1000Hz.			80mΩ (After charge)		
Charge	**Standard**		11mA × 15h		
	Quick		—		
	Trickle	**Max.**	5.5mA		
		Min.	3.7mA		
Ambient temperature	**Charge**		0° to 65°C (32° to 149°F)		
	Disharge		−20° to 65°C (−4° to 149°F)		
	Storage		−20° to 45°C (−4° to 113°F)		

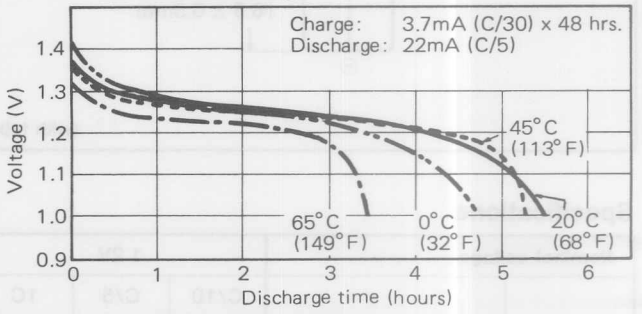
Note:
1. Nominal capacity, rated at C/5, 20°C
2. Other capacities are for reference.
3. See paragraph 1.6.2., for charging details.
4. Weight and internal impedance are for reference.
5. For bare cell, see page 75.

Typical characteristics

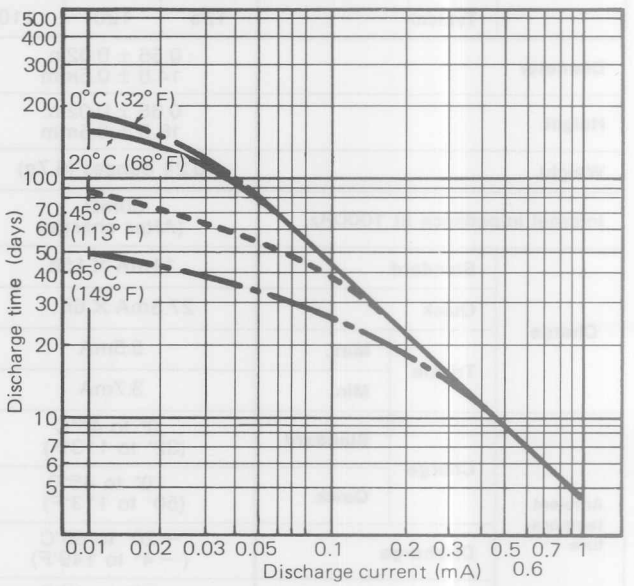
- **Trickle charge**



- **Low rate discharge**



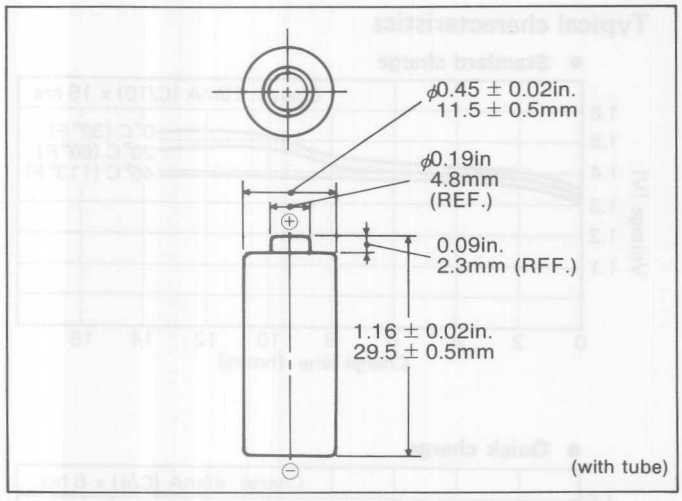
- **Very low rate discharge**



P-15N

Type: Standard
Size: N

150mAh



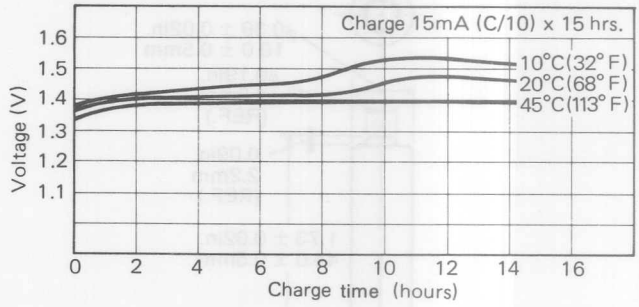
Specifications

Nominal voltage			1.2V		
Capacity (mAh)			C/10	C/5	1C
	Nominal		165	**150**	135
	Typical		180	165	150
Diameter			0.45 ± 0.02in. 11.5 ± 0.5mm		
Height			1.16 ± 0.02in. 29.5 ± 0.5mm		
Weight			0.29 ounces (8.2g)		
Internal impedance at 1000Hz.			40mΩ (After charge)		
Charge	**Standard**		15mA × 15h		
	Quick		38mA × 6h		
	Trickle	**Max.**	7.5mA		
		Min.	5mA		
Ambient temperature	**Charge**	**Standard**	0° to 45°C (32° to 113°F)		
		Quick	10° to 45°C (50° to 113°F)		
	Discharge		−20° to 65°C (−4° to 149°F)		
	Storage		−20° to 45°C (−4° to 113°F)		

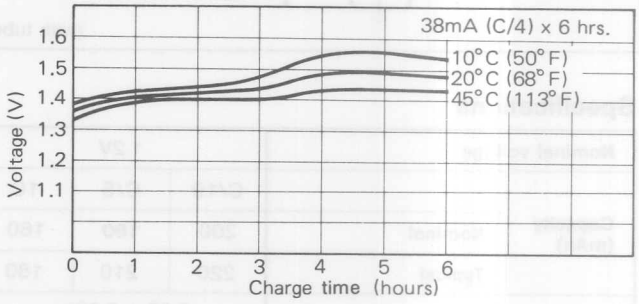
Note:
1. Nominal capacity, rated at C/5, 20°C
2. Other capacities are for reference.
3. See paragraph 1.6.2., for charging details.
4. Weight and internal impedance are for reference.
5. For bare cell, see page 75.

Typical characteristics

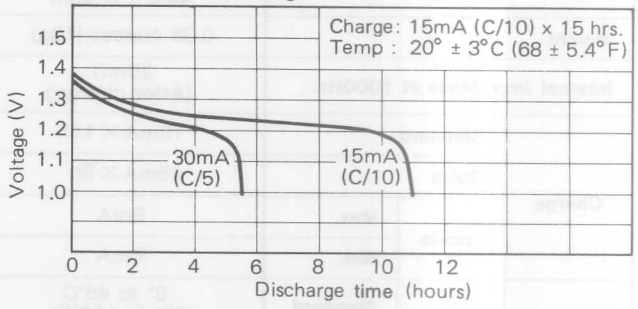
- **Standard charge**



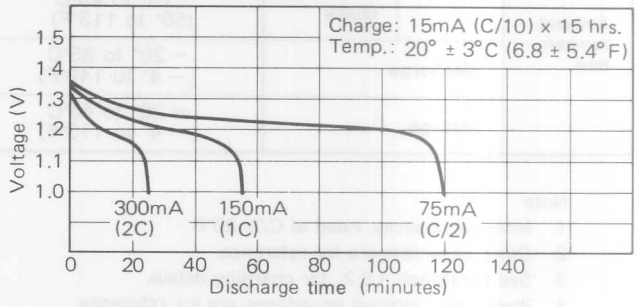
- **Quick charge**



- **Low rate discharge**



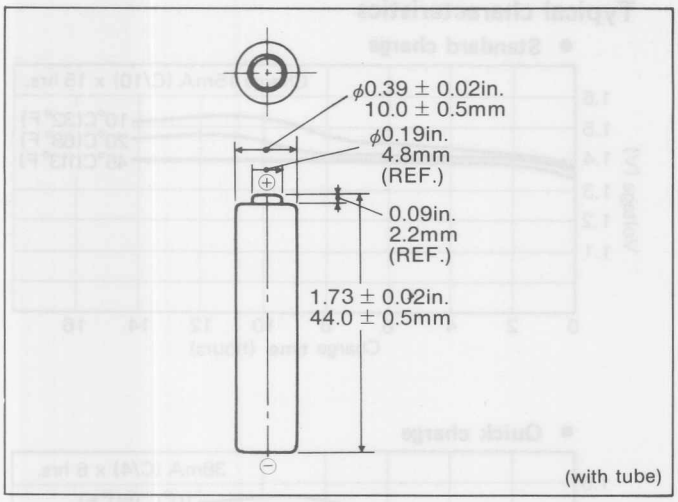
- **High rate discharge**



P-18AAA

Type: Standard
Size: AAA

180mAh



Specifications

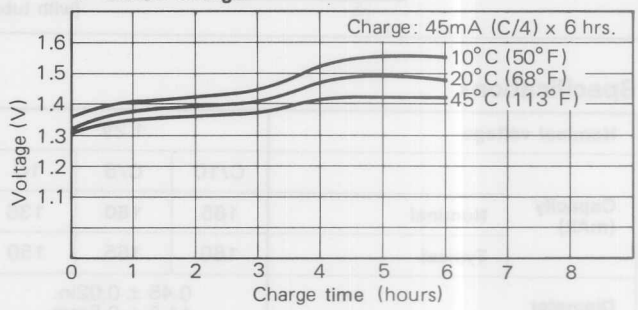
Nominal voltage			1.2V		
Capacity (mAh)			C/10	C/5	1C
	Nominal		200	**180**	160
	Typical		220	210	180
Diameter			0.39 ± 0.02in. 10.0 ± 0.5mm		
Height			1.73 ± 0.02in. 44.0 ± 0.5mm		
Weight			0.35 ounces (10g)		
Internal impedance at 1000Hz.			20mΩ (After charge)		
Charge	**Standard**		18mA × 15h		
	Quick		45mA × 6h		
	Trickle	**Max.**	9mA		
		Min.	6mA		
Ambient temperature	**Charge**	**Standard**	0° to 45°C (32° to 113°F)		
		Quick	10° to 45°C (50° to 113°F)		
	Discharge		−20° to 65°C (−4° to 149°F)		
	Storage		−20° to 45°C (−4° to 113°F)		

Note:
1. Nominal capacity, rated at C/5, 20°C
2. Other capacities are for reference.
3. See paragraph 1.6.2., for charging details.
4. Weight and internal impedance are for reference
5. For bare cell, see page 75.

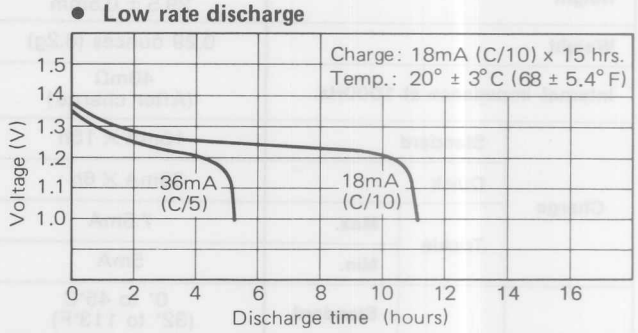
Typical characteristics

- **Standard charge**

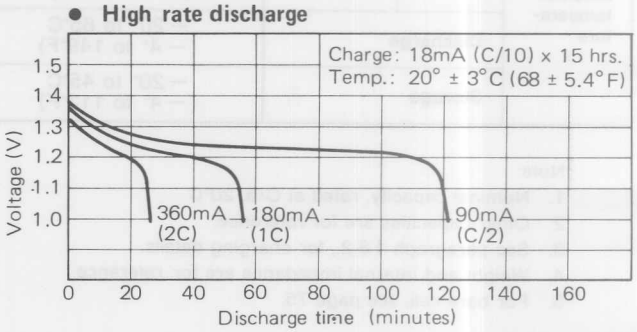
- **Quick charge**



- **Low rate discharge**



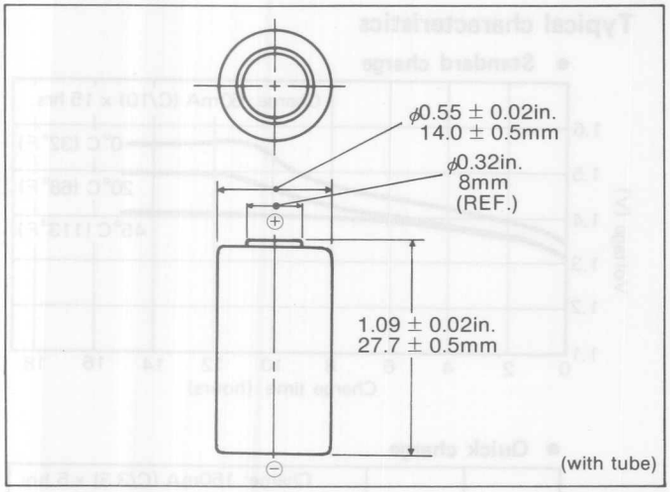
- **High rate discharge**



P-25AA

Type: Standard
Size: 2/3 AA (1/2 AA)

250mAh



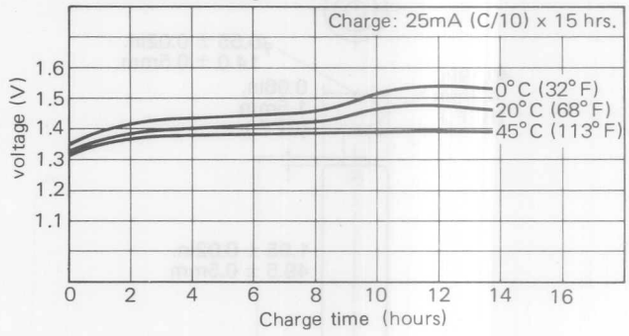
Specifications

Nominal voltage			1.2V		
Capacity (mAh)			C/10	C/5	1C
	Nominal		260	**250**	215
	Typical		290	280	250
Diameter			0.55 ± 0.02in. 14.0 ± 0.5mm		
Height			1.09 ± 0.02in. 27.7 ± 0.5mm		
Weight			0.43 ounces (12.3g)		
Internal impedance at 1000Hz.			20mΩ (After charge)		
Charge	**Standard**		25mA×15h		
	Quick		75mA×5h		
	Trickle	**Max.**	13mA		
		Min.	8mA		
Ambient temperature	**Charge**	**Standard**	0° to 45°C (32° to 113°F)		
		Quick	10° to 45°C (50° to 149°F)		
	Discharge		−20° to 65°C (−4° to 149°F)		
	Storage		−20° to 45°C (−4° to 149°F)		

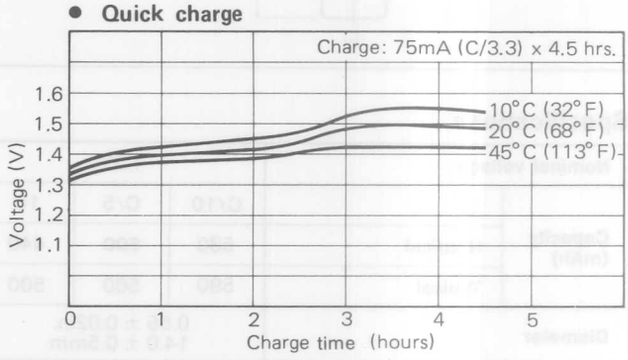
Note:
1. Nominal capacity, rated at C/5, 20°C
2. Other capacities are for reference.
3. See paragraph 1.6.2., for charging details.
4. Weight and internal impedance are for reference.
5. For bare cell, see page 75.

Typical characteristics

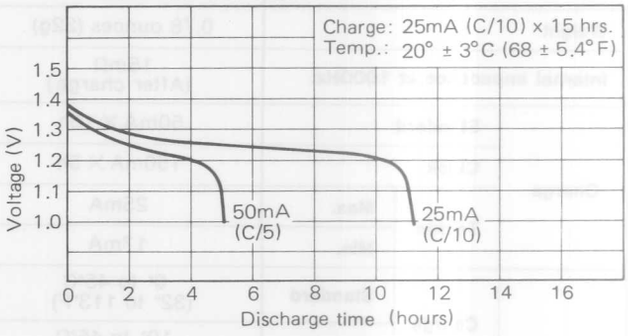
- **Standard charge**



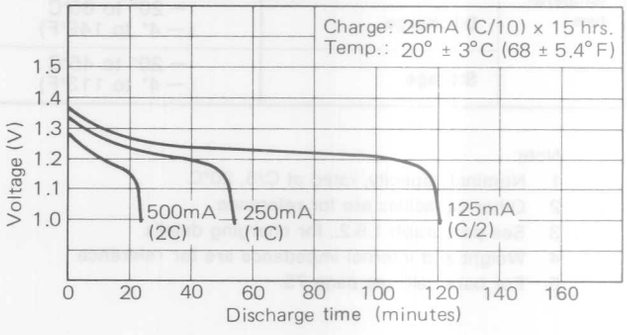
- **Quick charge**



- **Low rate discharge**



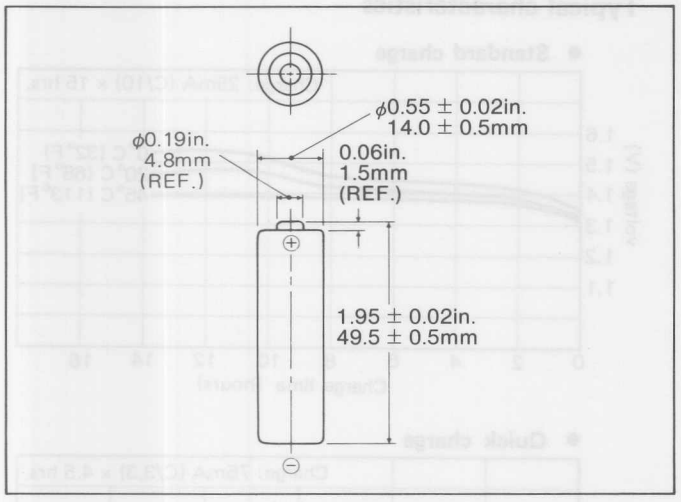
- **High rate discharge**



P-50AA

Type: Standard
Size: AA

500mAh



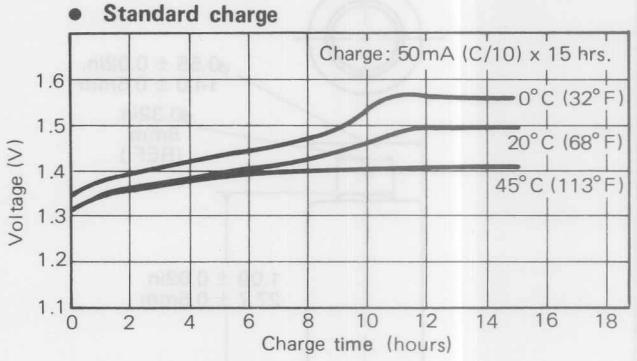
Specifications

Nominal voltage			1.2V		
Capacity (mAh)			C/10	C/5	1C
	Nominal		530	**500**	440
	Typical		590	560	500
Diameter			0.55 ± 0.02in. 14.0 ± 0.5mm		
Height			1.95 ± 0.02in. 49.5 ± 0.5mm		
Weight			0.78 ounces (22g)		
Internal impedance at 1000Hz.			15mΩ (After charge)		
Charge	**Standard**		50mA × 15h		
	Quick		150mA × 5h		
	Trickle	**Max.**	25mA		
		Min.	17mA		
Ambient temperature	**Charge**	**Standard**	0° to 45°C (32° to 113°F)		
		Quick	10° to 45°C (50° to 113°F)		
	Discharge		−20° to 65°C (−4° to 149°F)		
	Storage		−20° to 45°C (−4° to 113°F)		

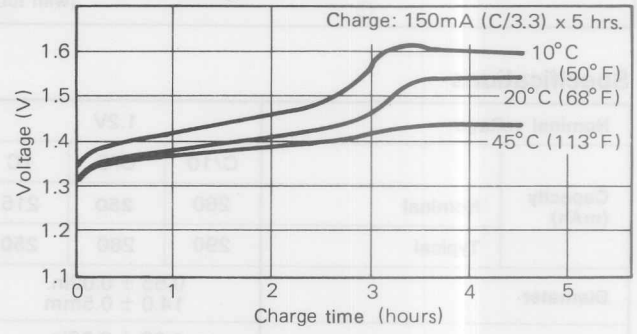
Note:
1. Nominal capacity, rated at C/5, 20°C
2. Other capacities are for reference.
3. See paragraph 1.6.2., for charging details.
4. Weight and internal impedance are for reference.
5. For bare cell, see page 75.

Typical characteristics

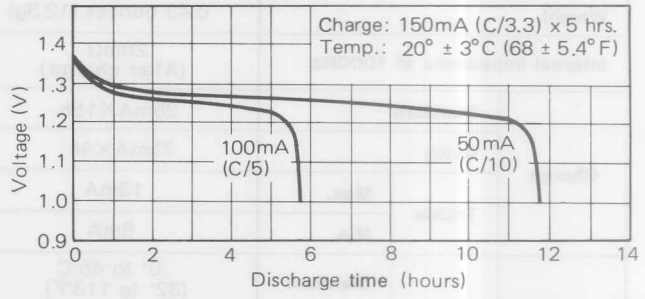
● **Standard charge**



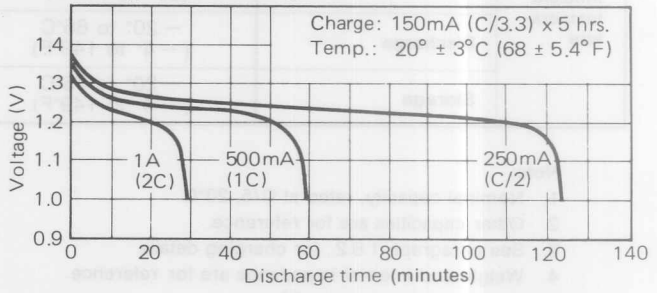
● **Quick charge**



● **Low rate discharge**



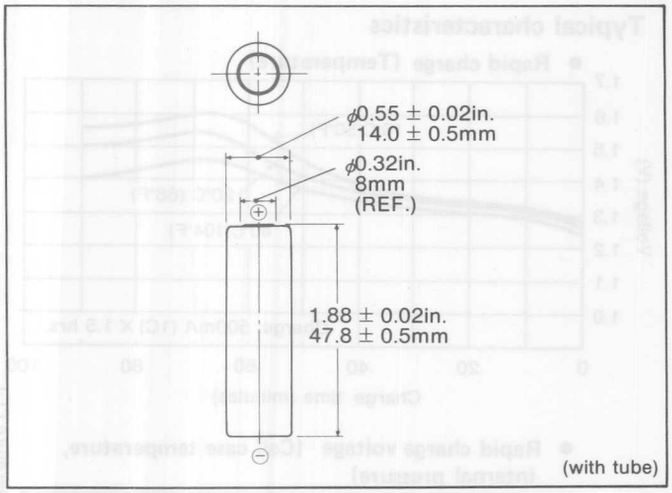
● **High rate discharge**



P-50AA/FT

Type: Standard
Size: AA

500mAh



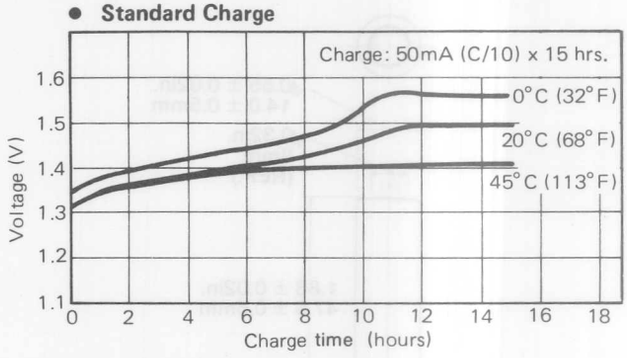
Specifications

Nominal voltage			1.2V		
Capacity (mAh)			C/10	C/5	1C
	Nominal		530	**500**	440
	Typical		590	560	500
Diameter			0.55 ± 0.02in. 14.0 ± 0.5mm		
Height			1.88 ± 0.02in. 47.8 ± 0.5mm		
Weight			0.78 ounces (22g)		
Internal impedance at 1000Hz.			15mΩ (After charge)		
Charge	**Standard**		50mA × 15h		
	Quick		150mA × 5h		
	Trickle	**Max.**	25mA		
		Min.	17mA		
Ambient temperature	**Charge**	**Standard**	0° to 45°C (32° to 113°F)		
		Quick	10° to 45°C (50° to 113°F)		
	Discharge		−20° to 65°C (−4° to 149°F)		
	Storage		−20° to 45°C (−4° to 113°F)		

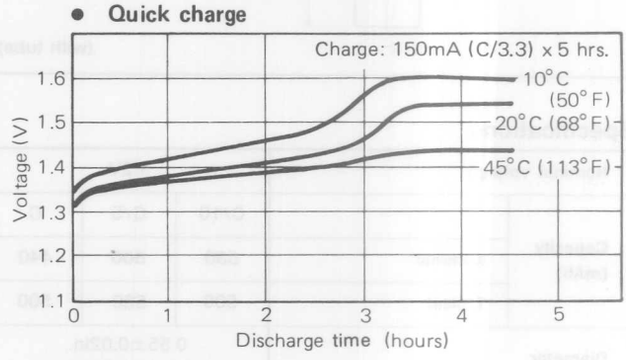
Note:
1. Nominal capacity, rated at C/5, 20°C
2. Other capacities are for reference.
3. See paragraph 1.6.2., for charging details.
4. Weight and internal impedance are for reference.
5. For bare cell, see page 75.

Typical characteristics

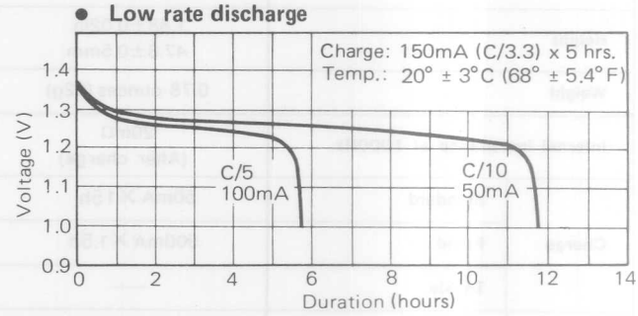
● **Standard Charge**



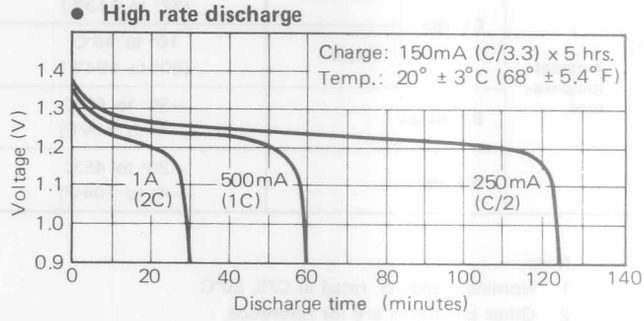
● **Quick charge**



● **Low rate discharge**



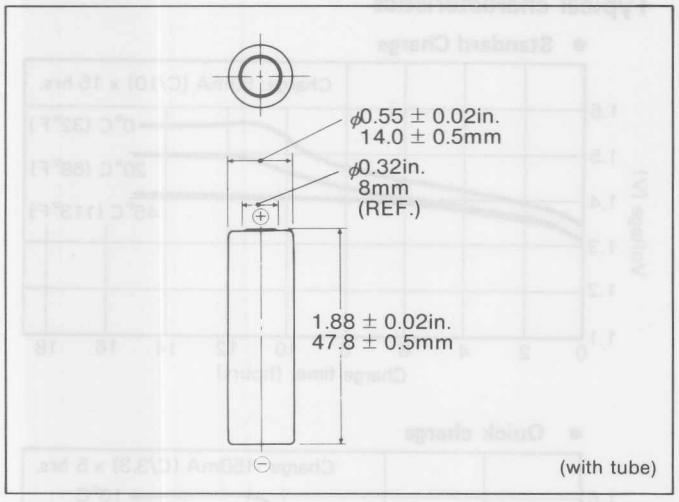
● **High rate discharge**



P-50AAR

Type: Rapid Charge "R"
Size: AA

500mAh



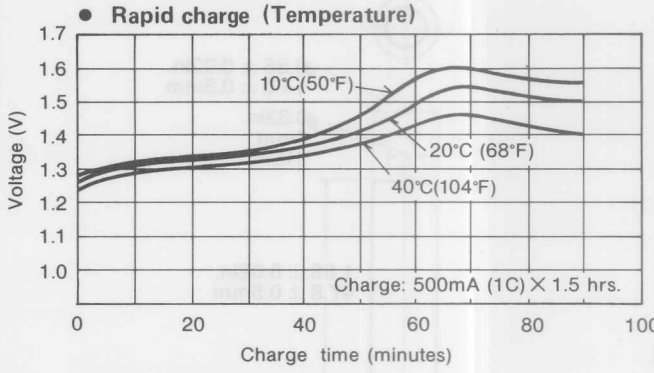
Specifications

Nominal voltage			1.2V		
Capacity (mAh)			C/10	C/5	C
	Nominal		530	500	440
	Typical		590	560	500
Diameter			0.55±0.02in. 14.0±0.5mm		
Height			1.88±0.02in. 47.8±0.5mm		
Weight			0.78 ounces (22g)		
Internal impedance at 1000Hz.			20mΩ (After charge)		
Charge	Standard		50mA ×15h		
	Rapid		500mA ×1.5h		
	Trickle		—		
Ambient temperature	Charge	Standard	0° to 45°C (32° to 113°F)		
		Rapid	10° to 40°C (50° to 104°F)		
	Discharge		−20° to 65°C (−4° to 149°F)		
	Storage		−20° to 45°C (−4° to 104°F)		

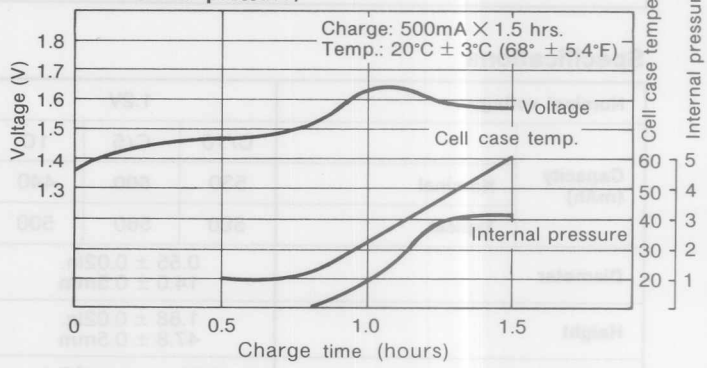
Note:
1. Nominal capacity, rated at C/5, 20°C
2. Other capacities are for reference.
3. See paragraph 1.6.2., for charging details.
4. Weight and internal impedance are for reference.
5. For bare cell, see page 75.

Typical characteristics

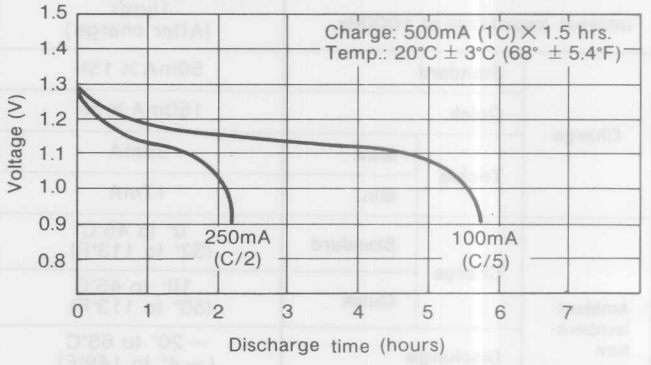
● **Rapid charge (Temperature)**



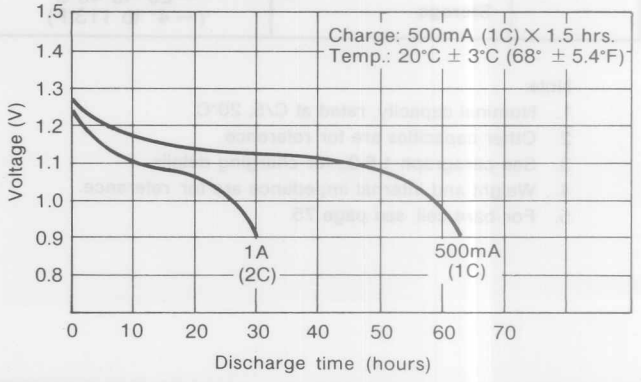
● **Rapid charge voltage (Cell case temperature, internal pressure)**



● **Low rate discharge**



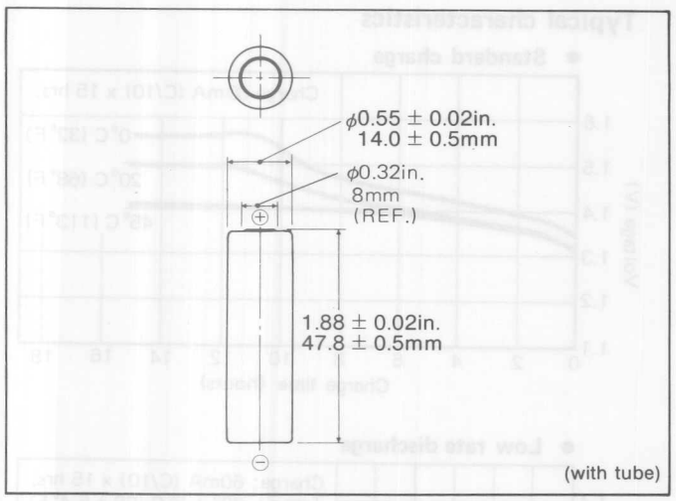
● **High rate discharge**



P-50AAH

Type: Memory Back-up Type
Size: AA

500mAh



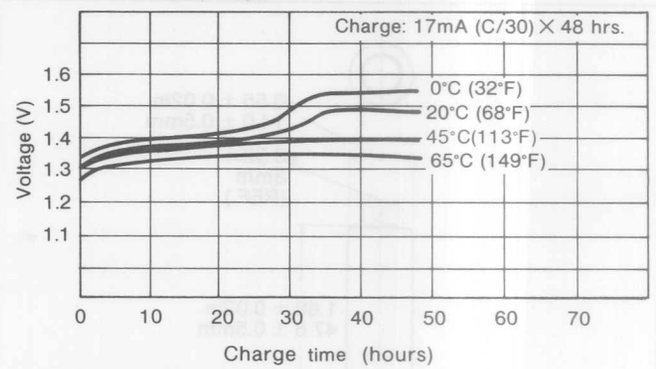
Specifications

Nominal voltage			1.2V		
Capacity (mAh)			C/10	C/5	1C
	Nominal		530	**500**	440
	Typical		590	560	500
Diameter			0.55 ± 0.02in. 14.0 ± 0.5mm		
Height			1.88 ± 0.02in. 47.8 ± 0.5mm		
Weight			0.78 ounces (22g)		
Internal impedance at 1000Hz.			18mΩ (After charge)		
Charge	**Standard**		50mA (C/10) × 15h		
	Quick		——		
	Trickle	**Max.**	25mA		
		Min.	17mA		
Ambient temperature	**Charge**		0° to 65°C (32° to 149°F)		
	Discharge		−20° to 65°C (−4° to 149°F)		
	Storage		−20° to 45°C (−4° to 113°F)		

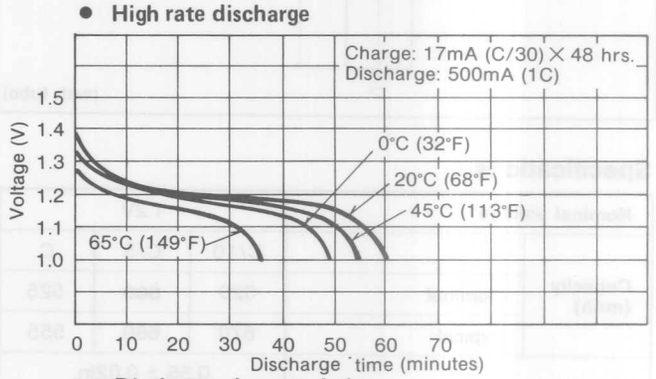
Note:
1. Nominal capacity, rated at C/5, 20°C
2. Other capacities are for reference.
3. See paragraph 1.6.2., for charging details.
4. Weight and internal impedance are for reference.
5. For bare cell, see page 75.

Typical characteristics

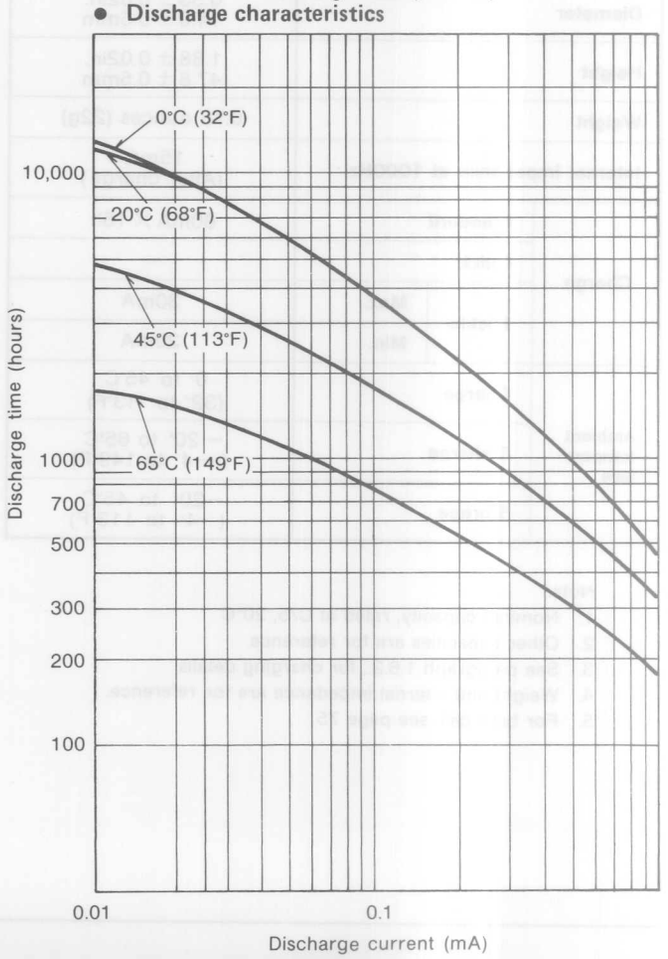
- **Trickle charge**



- **High rate discharge**



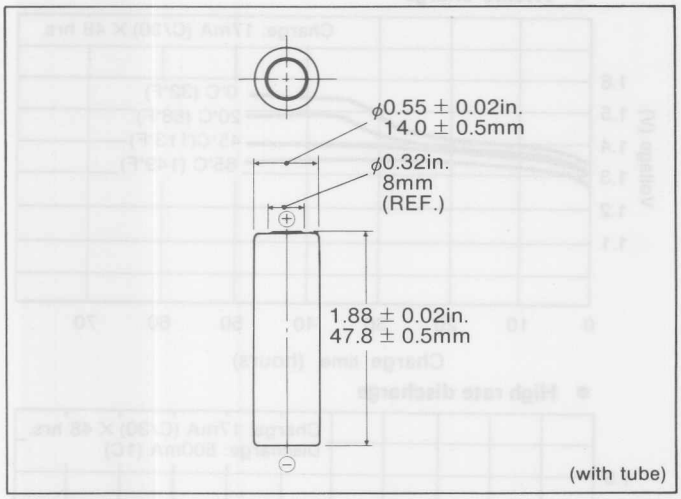
- **Discharge characteristics**



P-60AAE

Type: High Capacity "E"
Size: AA

600mAh



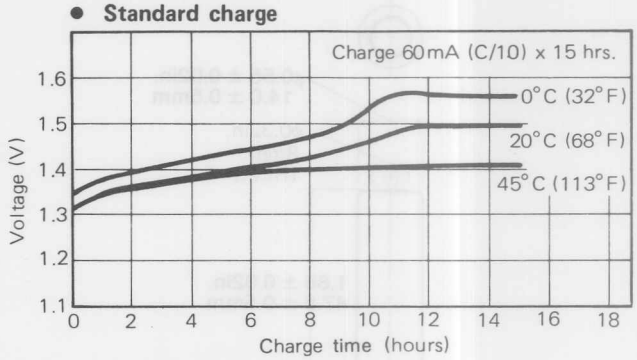
Specifications

Nominal voltage			1.2V		
Capacity (mAh)			C/10	C/5	C
	Nominal		620	**600**	525
	Typical		670	660	555
Diameter			0.55 ± 0.02in. 14.0 ± 0.5mm		
Height			1.88 ± 0.02in. 47.8 ± 0.5mm		
Weight			0.78 ounces (22g)		
Internal impedance at 1000Hz.			15mΩ (After charge)		
Charge	**Standard**		60mA × 15h		
	Quick		—		
	Trickle	**Max.**	30mA		
		Min.	20mA		
Ambient temperature	**Charge**		0° to 45°C (32° to 113°F)		
	Disharge		−20° to 65°C (−4° to 149°F)		
	Storage		−20° to 45°C (−4° to 113°F)		

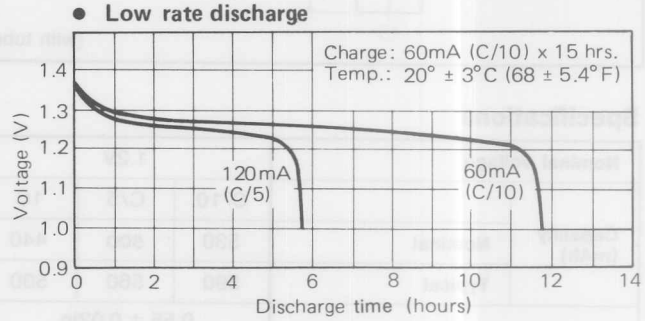
Note:
1. Nominal capacity, rated at C/5, 20°C
2. Other capacities are for reference.
3. See paragraph 1.6.2., for charging details.
4. Weight and internal impedance are for reference.
5. For bare cell, see page 75.

Typical characteristics

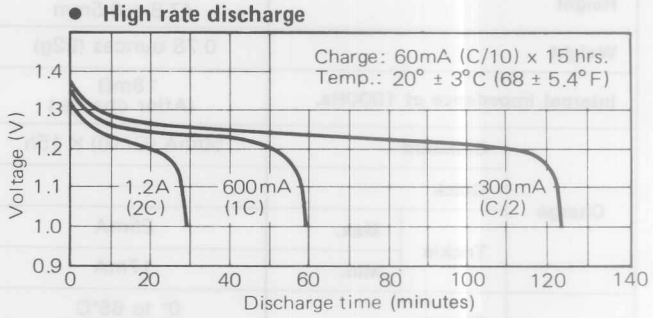
- **Standard charge**



- **Low rate discharge**



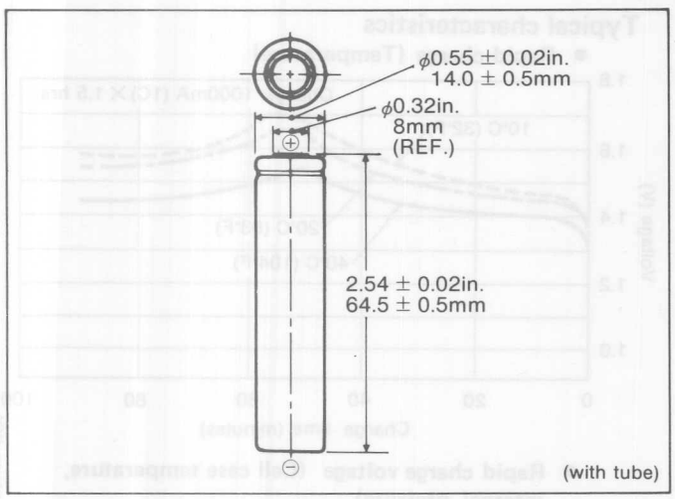
- **High rate discharge**



P-80AAR

Type: Rapid Charge "R"
Size: 5/4 AA

750mAh



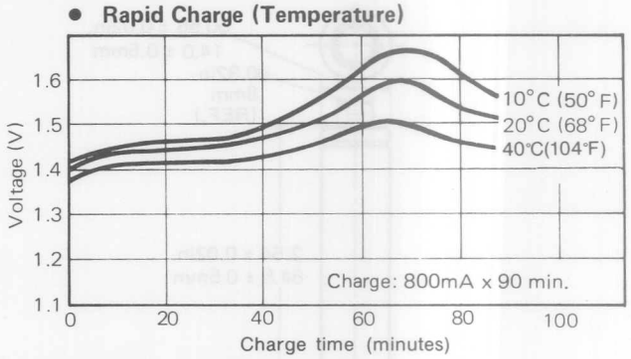
Specifcations

Nominal voltage		1.2V		
Capacity (mAh)		C/10	C/5	C
	Nominal	790	**750**	680
	Typical	840	850	720
Diameter		0.55 ± 0.02in. 14.0 ± 0.5mm		
Height		2.54 ± 0.02in. 64.5 ± 0.5mm		
Weight		1.02 ounces (29g)		
Internal impedance at 1000Hz.		15mΩ (After Charge)		
Charge	**Standard**	80mA×15h		
	Rapid	800mA×1.5h		
	Trickle	—		
Ambient temperature	**Rapid Charge**	10° to 40°C (50° to 104°F)		
	Discharge	−20° to 65°C (−4° to 149°F)		
	Storage	−20° to 65°C (−4° to 113°F)		

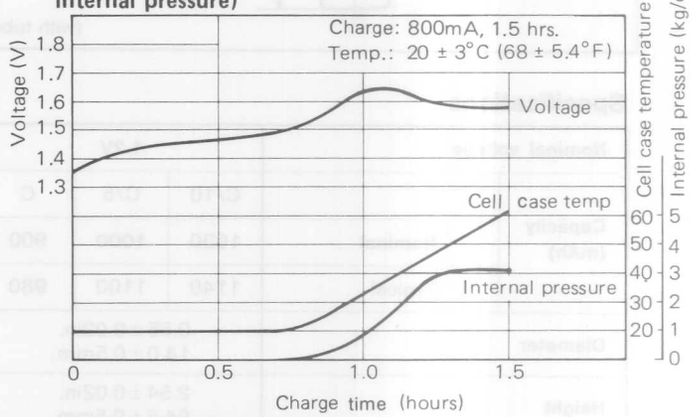
Note:
1. Nominal capacity, rated at C/5, 20°C
2. Other capacities are for reference.
3. See paragraph 1.6.2., for charging details.
4. Weight and internal impedance are for reference.
5. For bare cell, see page 75.

Typical characteristics

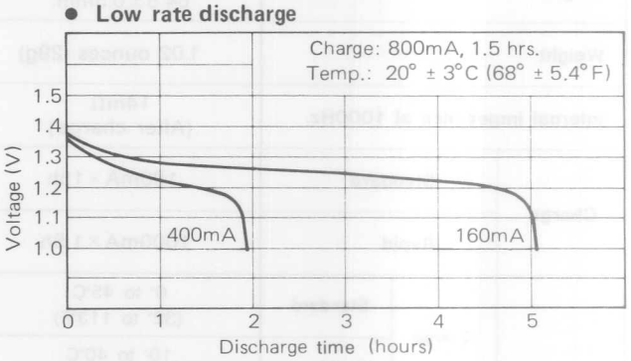
- **Rapid Charge (Temperature)**



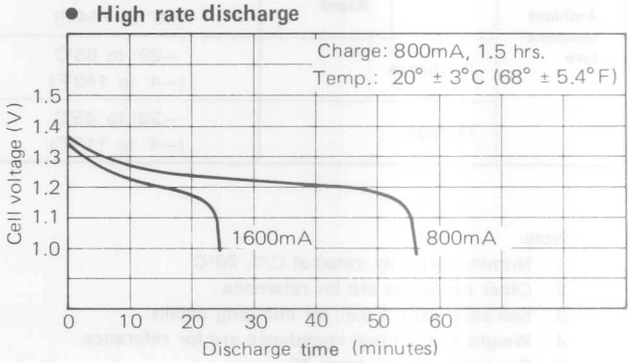
- **Rapid charge (Voltage, cell case temperature, internal pressure)**



- **Low rate discharge**



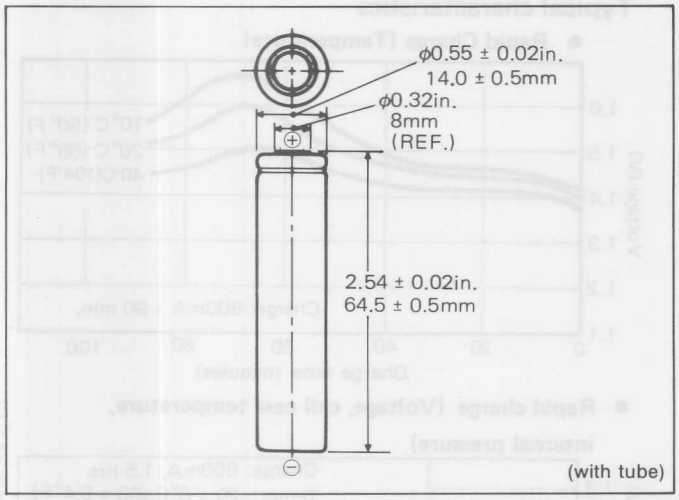
- **High rate discharge**



P-100AAS

Type : Super high capacity & rapid charge "S"
Size : 5/4 AA

1000mAh



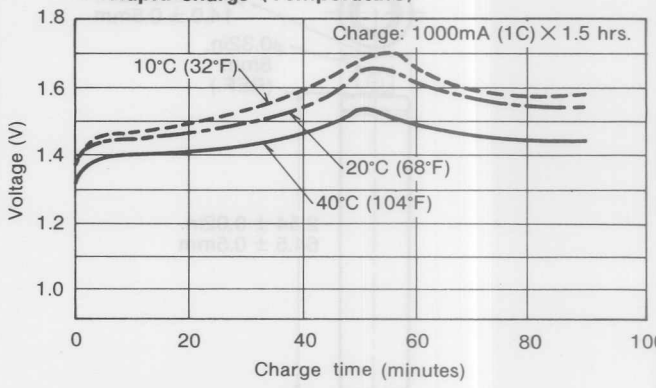
Specifications

Nominal voltage			**1.2V**		
Capacity (mAh)			C/10	C/5	C
	Nominal		1030	**1000**	900
	Typical		1140	1100	980
Diameter			0.55±0.02in. 14.0±0.5mm.		
Height			2.54±0.02in. 64.5±0.5mm.		
Weight			1.02 ounces (29g)		
Internal impedance at 1000Hz.			14mΩ (After charge)		
Charge	**Standard**		100mA×15h		
	Rapid		1000mA×1.5h		
Ambient temperature	**Charge**	**Standard**	0° to 45°C (32° to 113°F)		
		Rapid	10° to 40°C (50° to 104°F)		
	Discharge		−20° to 65°C (−4° to 149°F)		
	Storage		−20° to 45°C (−4° to 113°F)		

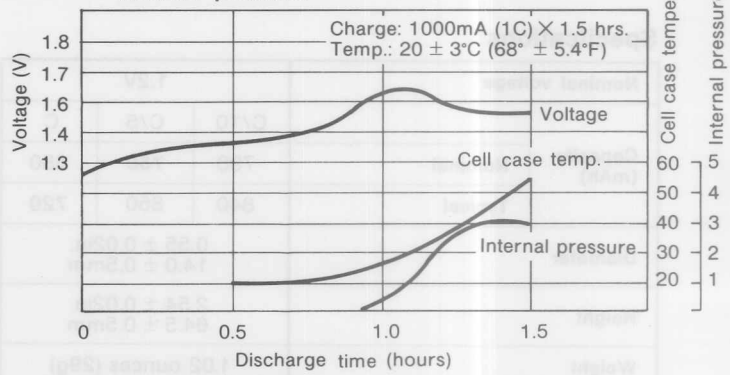
Note:
1. Nominal capacity, rated at C/5, 20°C
2. Other capacities are for reference.
3. See paragraph 1.6.2., for charging details.
4. Weight and internal impedance are for reference.
5. For bare cell, see page 75.

Typical characteristics

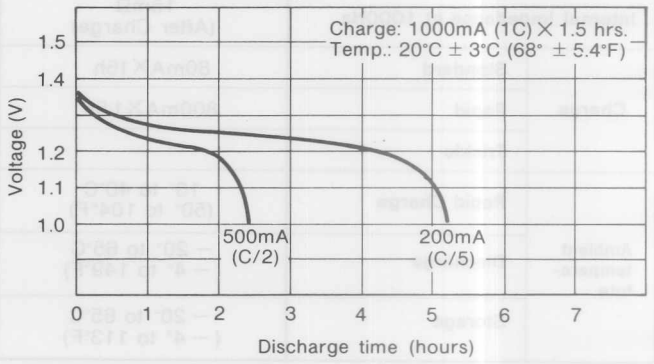
- **Rapid charge (Temperature)**



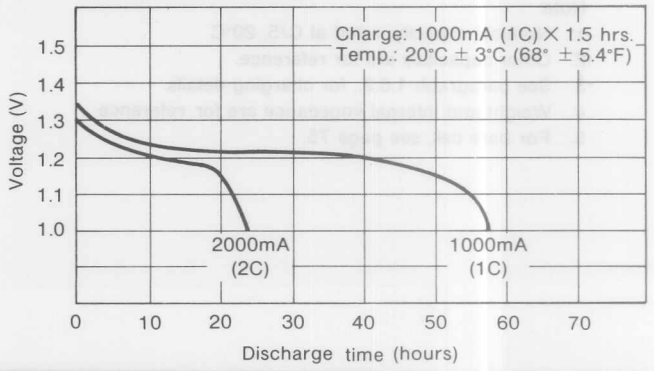
- **Rapid charge voltage (Cell case temperature, internal pressure)**



- **Low rate discharge**



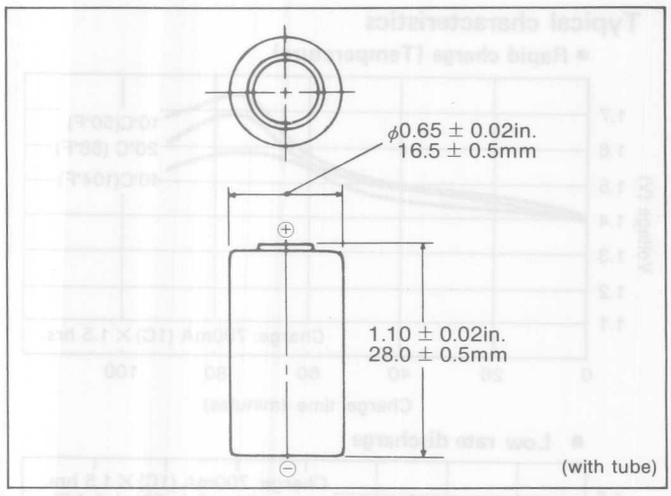
- **High rate discharge**



P-40AR

Type: Rapid Charge "R"
Size: 2/3 Af

425mAh



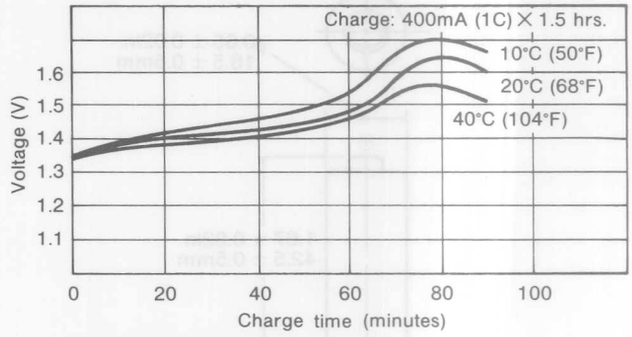
Specifications

Nominal voltage			1.2V		
Capacity (mAh)			C/10	C/5	C
	Nominal		430	**425**	380
	Typical		480	460	440
Diameter			0.65±0.02in. 16.5±0.5mm		
Height			1.10±0.03in. 28.0±0.75mm		
Weight			0.63ounces(18g)		
Internal impedance at 1000Hz.			18mΩ (After charge)		
Charge	Standard		40mA×15h		
	Rapid		400mA×1.5h		
	Trickle		—		
Ambient temperature	Charge	Standard	0° to 45°C (32° to 113°F)		
		Rapid	10° to 40°C (50° to 104°F)		
	Discharge		−20° to 65°C (−4° to 149°F)		
	Storage		−20° to 45°C (−4° to 113°F)		

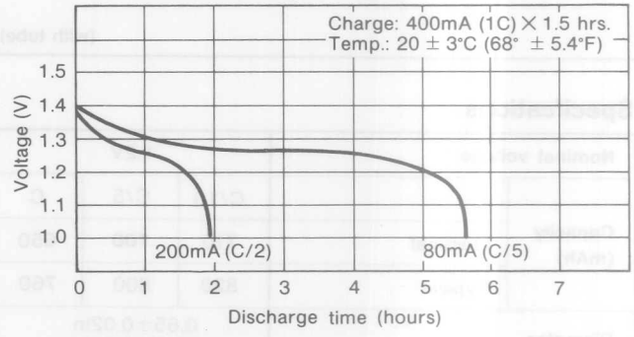
Note:
1. Nominal capacity, rated at C/5, 20°C
2. Other capacities are for reference.
3. See paragraph 1.6.2., for charging details.
4. Weight and internal impedance are for reference.
5. For bare cell, see page 75.

Typical characteristics

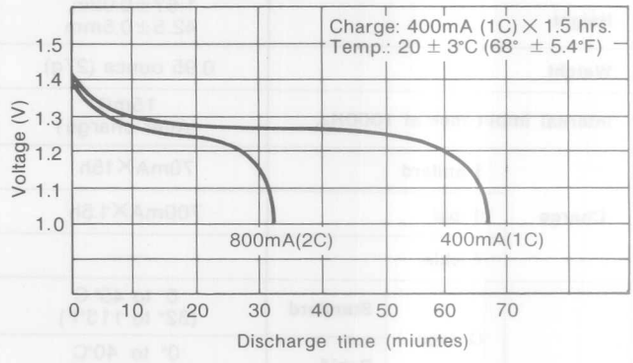
- **Rapid charge (Temperature)**



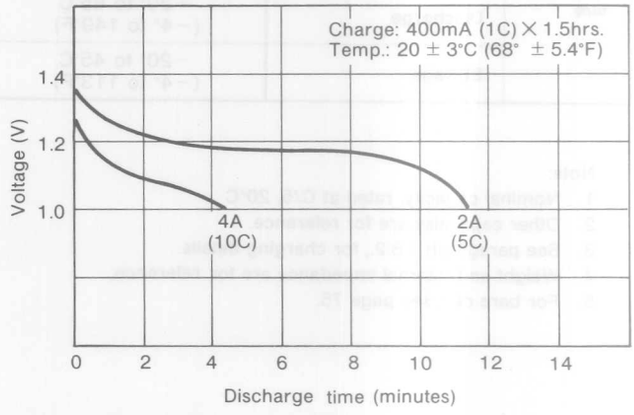
- **Low rate discharge**



- **High rate discharge (1)**



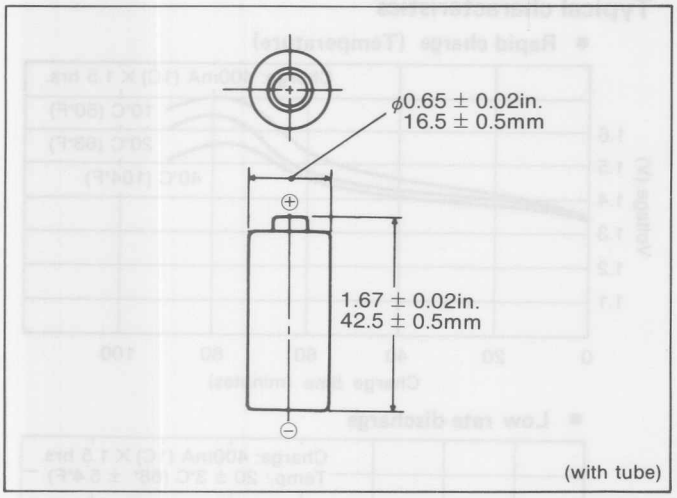
- **High rate discharge (2)**



P-70AR

Type: Rapid Charge "R"
Size: 4/5 Af

700mAh



(with tube)

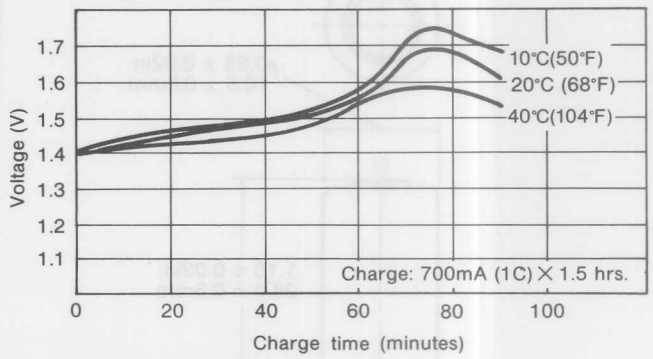
Specifcations

Nominal voltage			1.2V		
Capacity (mAh)			C/10	C/5	C
	Nominal		710	**700**	650
	Typical		820	800	760
Diameter			0.65±0.02in. 16.5±0.5mm		
Height			1.67±0.02in. 42.5±0.5mm		
Weight			0.95 ounce (27g)		
Internal impedance at 1000Hz.			15mΩ (After charge)		
Charge	**Standard**		70mA×15h		
	Rapid		700mA×1.5h		
	Trickle		—		
Ambient temperature	**Charge**	**Standard**	0° to 45°C (32° to 113°F)		
		Rapid	0° to 40°C (50° to 104°F)		
	Discharge		−20° to 65°C (−4° to 149°F)		
	Storage		−20° to 45°C (−4° to 113°F)		

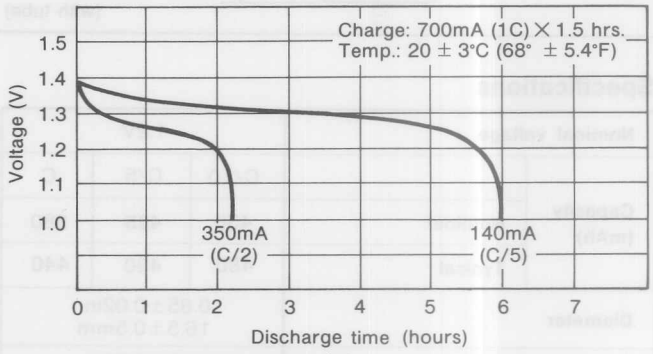
Note:
1. Nominal capacity, rated at C/5, 20°C
2. Other capacities are for reference.
3. See paragraph 1.6.2., for charging details.
4. Weight and internal impedance are for reference.
5. For bare cell, see page 75.

Typical characteristics

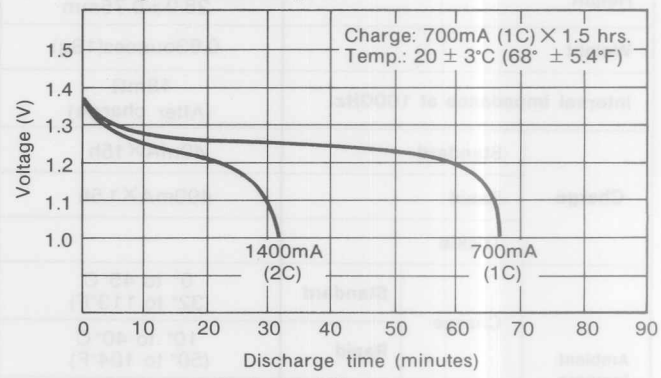
● **Rapid charge (Temperature)**



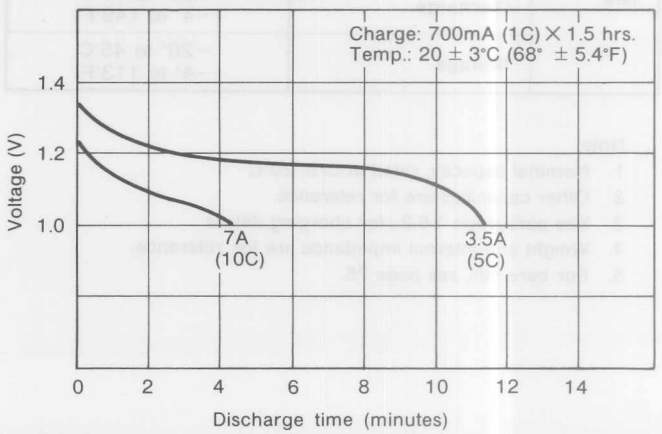
● **Low rate discharge**



● **High rate discharge (1)**



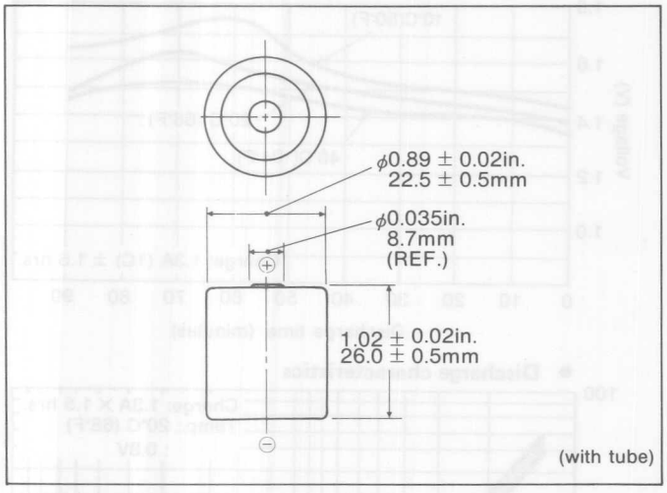
● **High rate discharge (2)**



P-60SC

Type: Standard
Size: 2/3 SC (1/2 SC)

600mAh



(with tube)

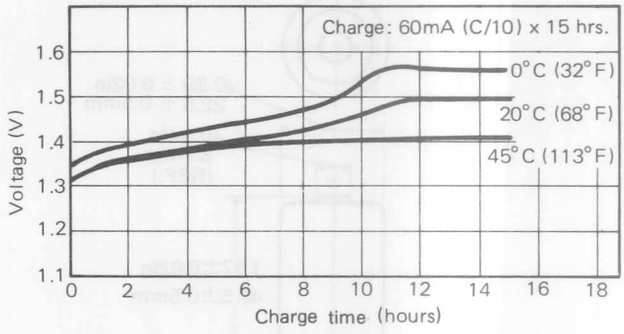
Specifications

Nominal voltage			1.2V		
Capacity (mAh)			C/10	C/5	1C
	Nominal		620	**600**	570
	Typical		720	700	620
Diameter			0.89 ± 0.02in. 22.5 ± 0.5mm		
Height			1.02 ± 0.02in. 26.0 ± 0.5mm		
Weight			1.02 ounces (29g)		
Internal impedance at 1000Hz.			25mΩ (After charge)		
Charge	**Standard**		60mA×15A		
	Quick		150mA (6Hrs.)		
	Trickle	**Max.**	30mA		
		Min.	20mA		
Ambient temperature	**Charge**	**Standard**	0° to 45°C (32° to 113°F)		
		Quick	10° to 45° C (50° to 113° F)		
	Discharge		−20° to 65°C (−4° to 149°F)		
	Storage		−20° to 45°C (−4° to 113°F)		

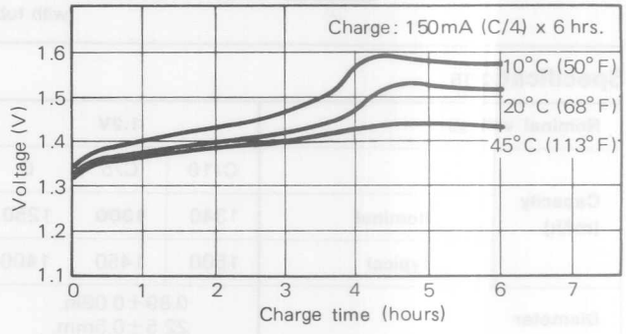
Note:
1. Nominal capacity, rated at C/5, 20°C
2. Other capacities are for reference.
3. See paragraph 1.6.2., for charging details.
4. Weight and internal impedance are for reference.
5. For bare cell, see page 75.

Typical characteristics

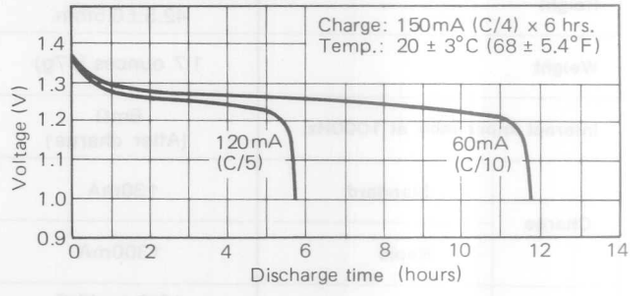
● **Standard charge**



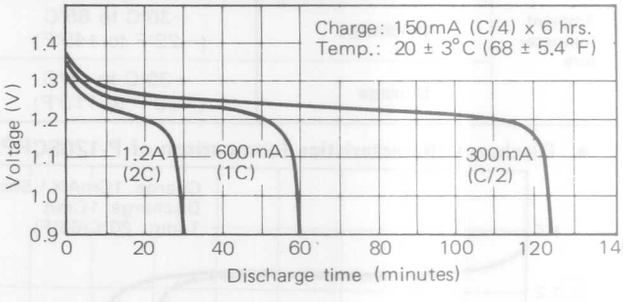
● **Quick charge**



● **Low rate discharge**



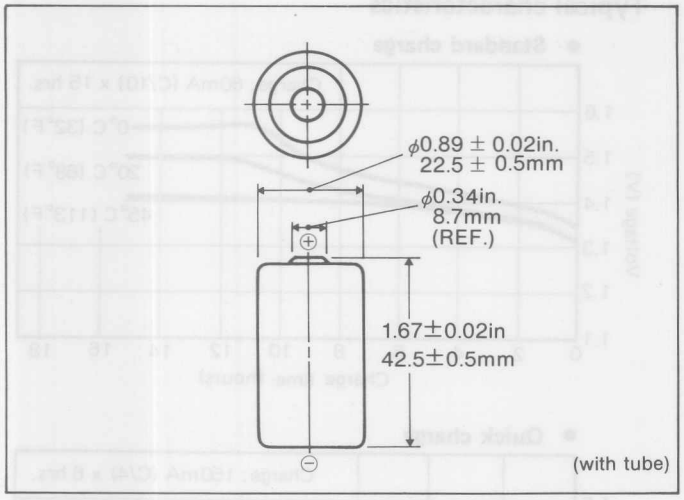
● **High rate discharge**



P-130SCR

Type : High rate discharge & rapid charge "R/P"
Size : SC

1300mAh

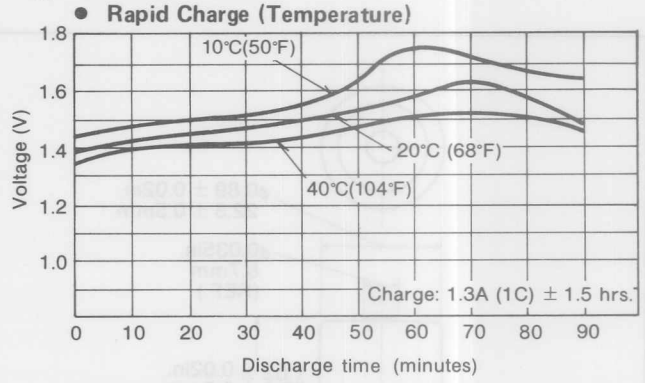


Specifications

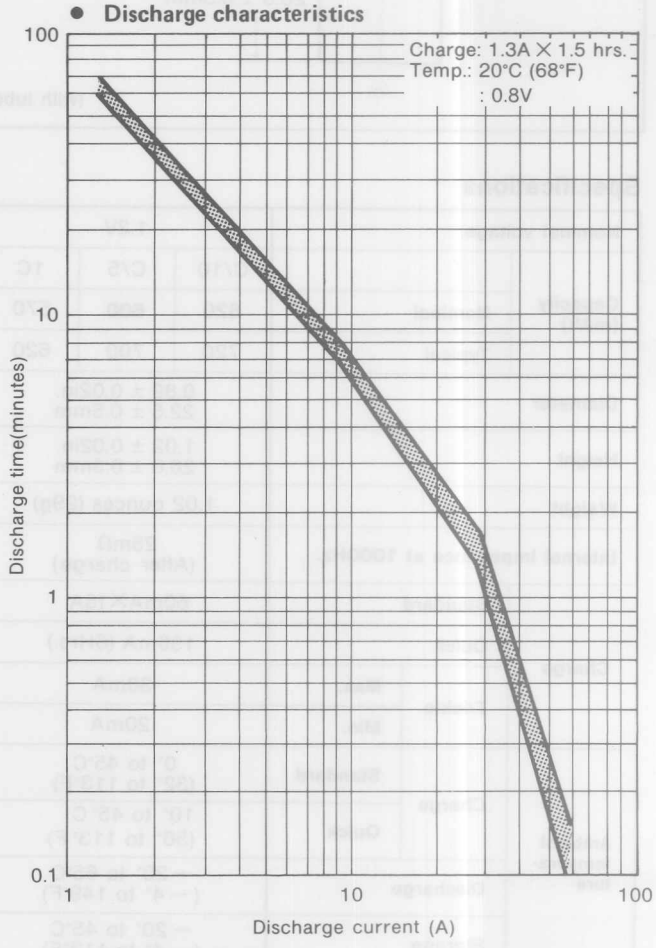
Nominal voltage		**1.2V**		
Capacity (mAh)		C/10	C/5	C
	Nominal	1340	**1300**	1250
	Typical	1500	1450	1400
Diameter		0.89±0.02in. 22.5±0.5mm.		
Height		1.67±0.02in. 42.5±0.5mm.		
Weight		1.7 ounces (47g)		
Internal impedance at 1000Hz.		6mΩ (After charge)		
Charge	**Standard**	130mA		
	Rapid	1300mA		
Ambient temperature	**Rapid charge**	10°C to 40°C (50°F to 104°F)		
	Discharge	−30°C to 65°C (−22°F to 149°F)		
	Storage	−30°C to 45°C (−22°F to 113°F)		

Typical characteristics

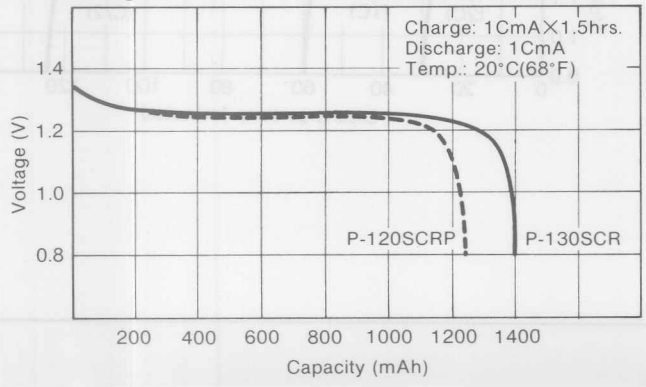
● **Rapid Charge (Temperature)**



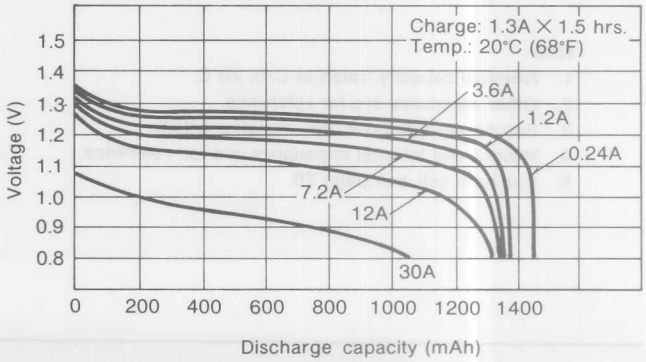
● **Discharge characteristics**



● **Discharge characteristics (comparison of P-120SCRP)**



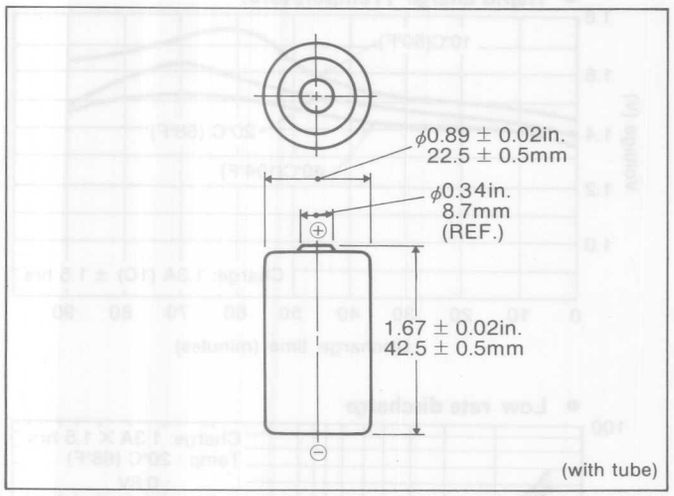
● **High rate discharge**



P-120SCRP

Type : High rate discharge & rapid charge "R/P"
Size : SC

1200mAh

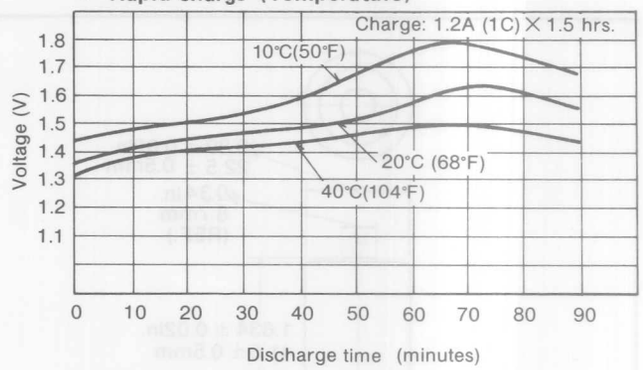


Specifications

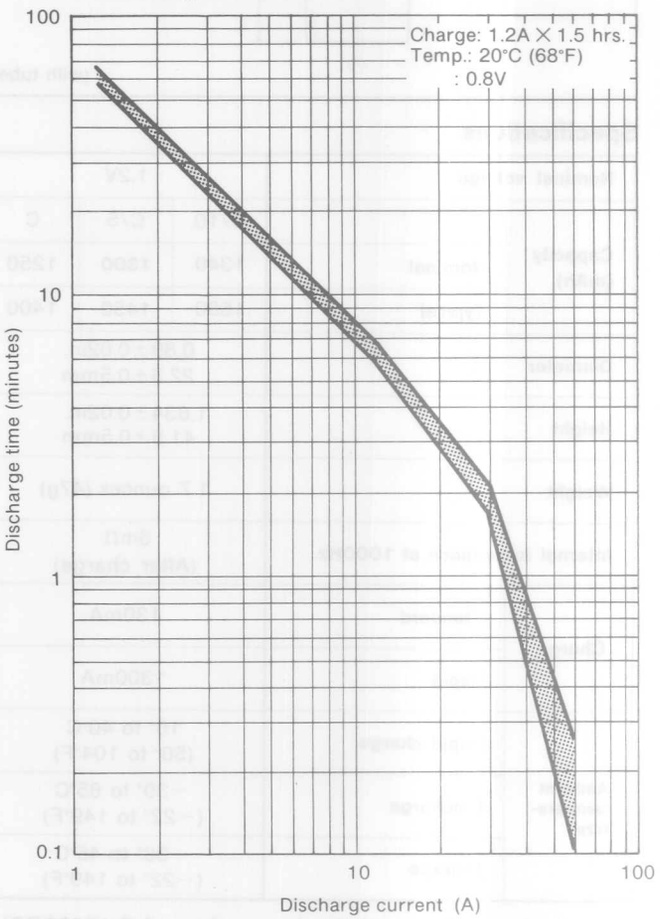
Nominal voltage		1.2V		
Capacity (mAh)		C/10	C/5	C
	Nominal	1230	**1200**	1150
	Typical	1390	1350	1300
Diameter		0.89±0.02in. 22.5±0.5mm.		
Height		1.67±0.02in. 42.5±0.5mm.		
Weight		1.7 ounces (47g)		
Internal impedance at 1000Hz.		5mΩ (After charge)		
Charge	Standard	120mA		
	Rapid	1200mA		
Ambient temperature	Rapid charge	10° to 40°C (50° to 104°F)		
	Discharge	−30° to 65°C (−22° to 149°F)		
	Storage	−30° to 45°C (−22° to 149°F)		

Typical characteristics

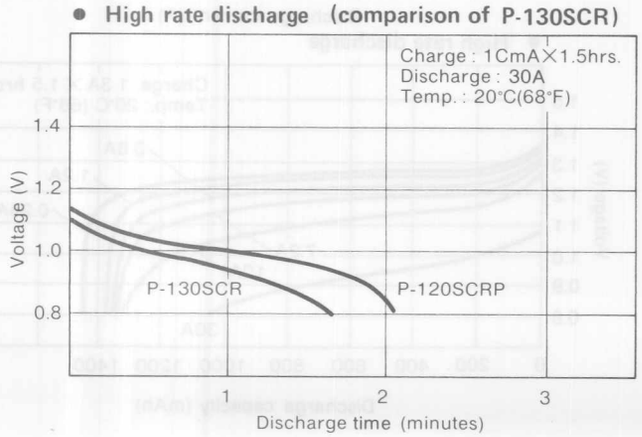
● Rapid charge (Temperature)



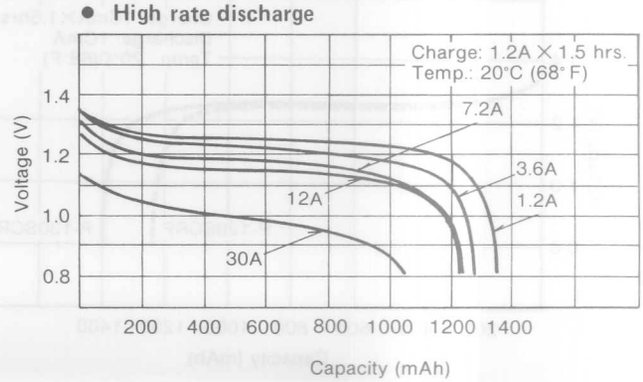
● Discharge characteristics



● High rate discharge (comparison of P-130SCR)



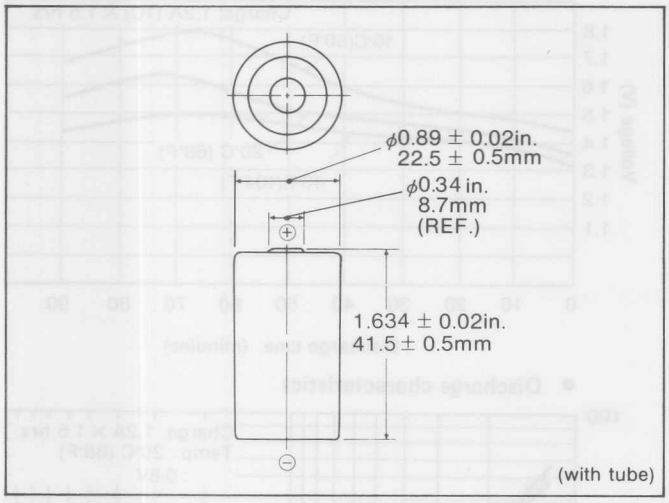
● High rate discharge



P130SCRC

Type : High rate discharge & rapid charge "R/P"
Size: SC compact

1300mAh

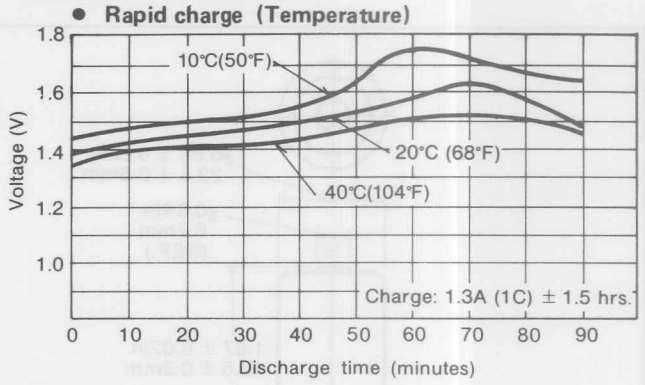


Specifications

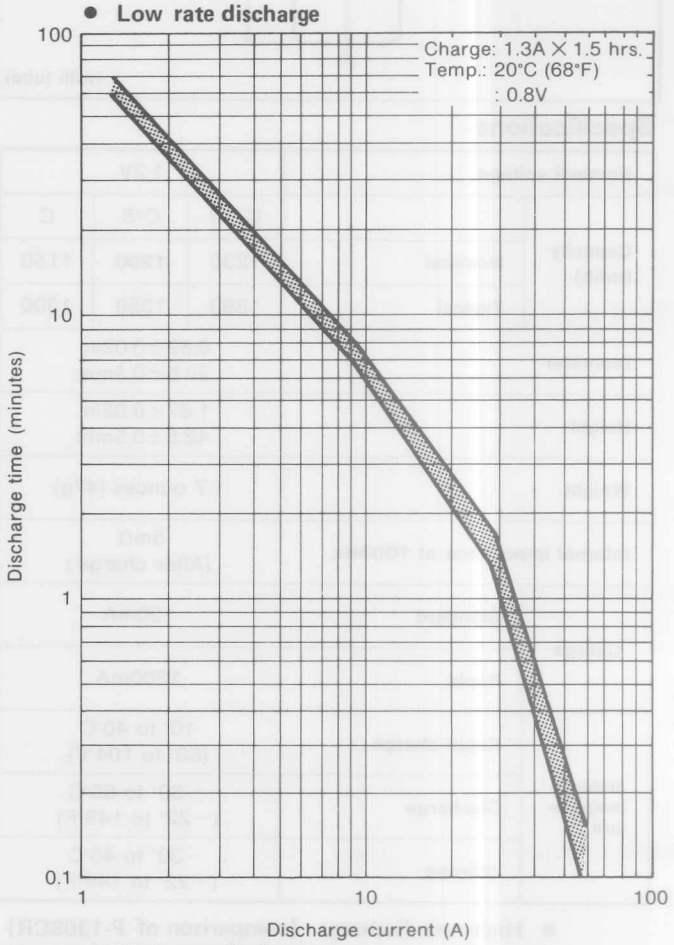
Nominal voltage		1.2V		
Capacity (mAh)		C/10	C/5	C
	Nominal	1340	**1300**	1250
	Typical	1500	1450	1400
Diameter		0.89±0.02in. 22.5±0.5mm		
Height		1.634±0.02in. 41.5±0.5mm		
Weight		1.7 ounces (47g)		
Internal impedance at 1000Hz.		6mΩ (After charge)		
Charge	**Standard**	130mA		
	Rapid	1300mA		
Ambient temperature	**Rapid charge**	10° to 40°C (50° to 104°F)		
	Discharge	−30° to 65°C (−22° to 149°F)		
	Storage	−30° to 45°C (−22° to 149°F)		

Typical characteristics

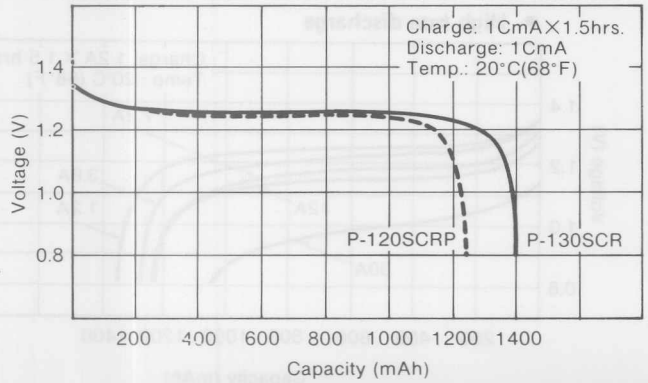
- **Rapid charge (Temperature)**



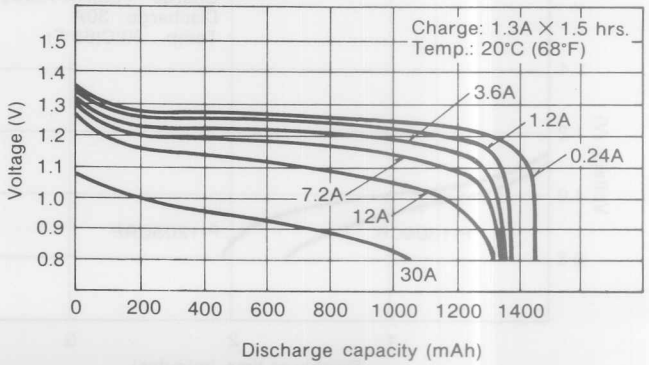
- **Low rate discharge**



- **Discharge characteristics (comparison of P-120SCRP)**



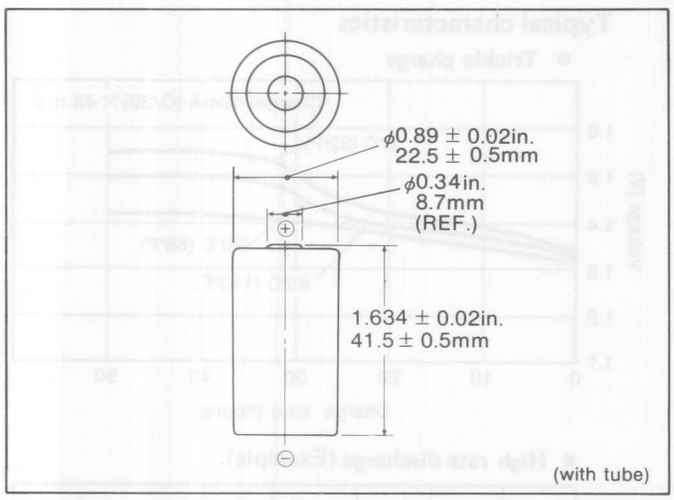
- **High rate discharge**



P-120SCPC

Type : High rate discharge & rapid charge "R/P"
Size : SC compact

1200mAh

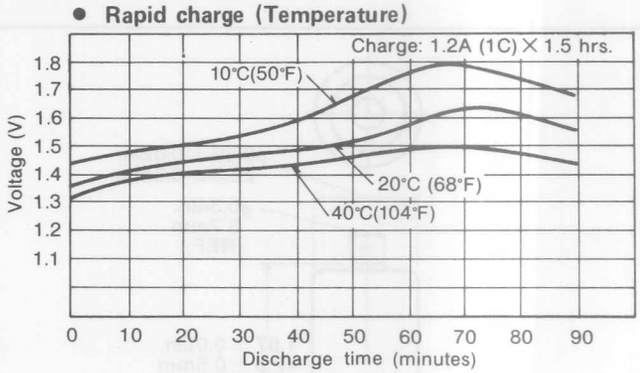


Specifications

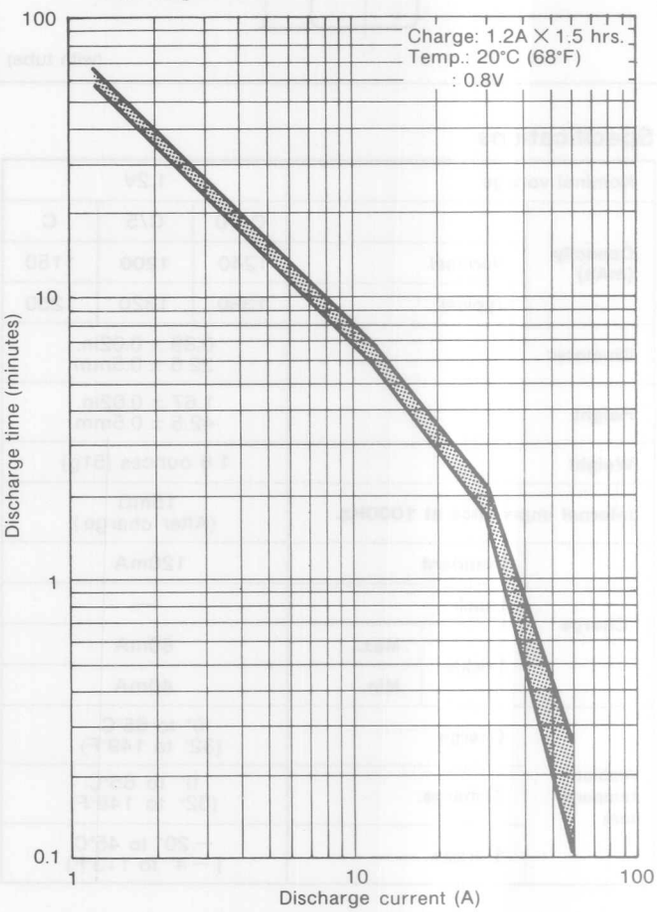
Nominal voltage		**1.2V**		
Capacity (mAh)		C/10	C/5	C
	Nominal	1230	**1200**	1150
	Typical	1390	1350	1300
Diameter		0.89±0.02in. 22.5±0.5mm.		
Height		1.634±0.02in. 41.5±0.5mm.		
Weight		1.7 ounces (47g)		
Internal impedance at 1000Hz.		5mΩ (After charge)		
Charge	**Standard**	120mA		
	Rapid	1200mA		
Ambient temperature	**Rapid charge**	10°C to 40°C (50°F to 104°F)		
	Discharge	−30°C to 65°C (−22°F to 149°F)		
	Storage	−30°C to 45°C (−22°F to 113°F)		

Typical characteristics

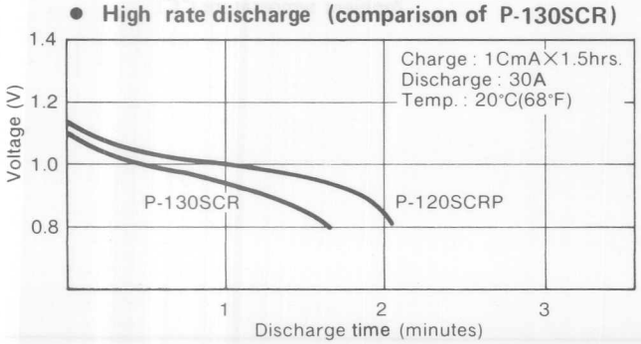
● **Rapid charge (Temperature)**



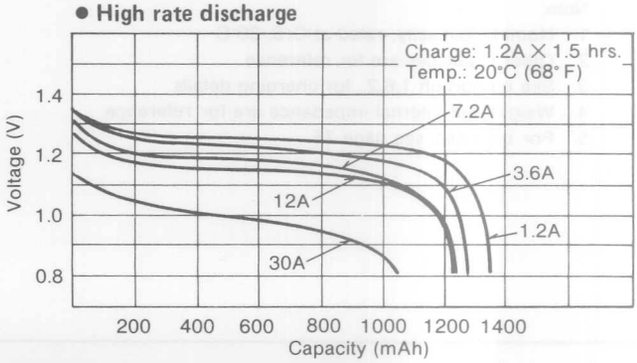
● **Discharge characteristics**



● **High rate discharge (comparison of P-130SCR)**



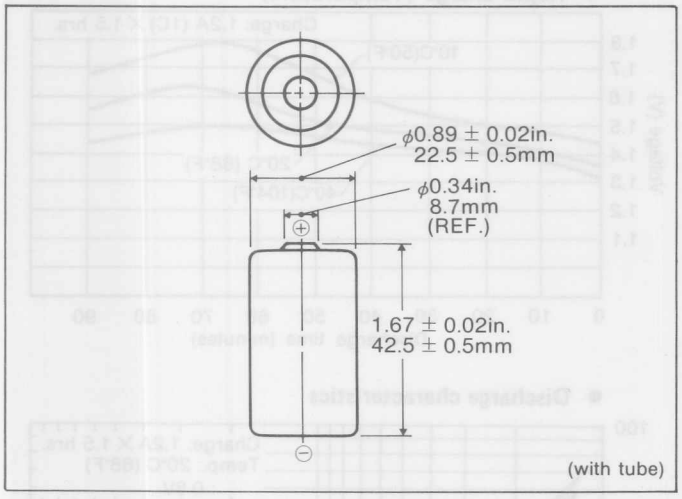
● **High rate discharge**



P-120SCH

Type: High temp. "H"
Size: SC

1200mAh



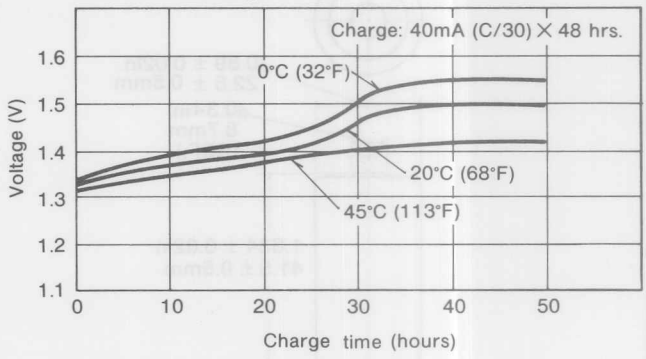
Specifications

Nominal voltage			1.2V		
Capacity (mAh)			C/10	C/5	C
	Nominal		1240	**1200**	1150
	Typical		1360	1320	1250
Diameter			0.89 ± 0.02in. 22.5 ± 0.5mm		
Height			1.67 ± 0.02in. 42.5 ± 0.5mm		
Weight			1.8 ounces (51g)		
Internal impedance at 1000Hz.			15mΩ (After charge)		
Charge	**Standard**		120mA		
	Quick		—		
	Trickle	**Max.**	60mA		
		Min.	40mA		
Ambient temperature	**Charge**		0° to 65°C (32° to 149°F)		
	Disharge		0° to 65°C (32° to 149°F)		
	Storage		−20° to 45°C (−4° to 113°F)		

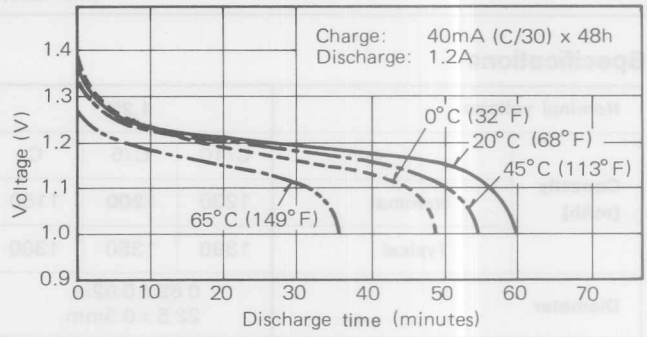
Note:
1. Nominal capacity, rated at C/5, 20°C
2. Other capacities are for reference.
3. See paragraph 1.6.2., for charging details.
4. Weight and internal impedance are for reference.
5. For bare cell, see page 75.

Typical characteristics

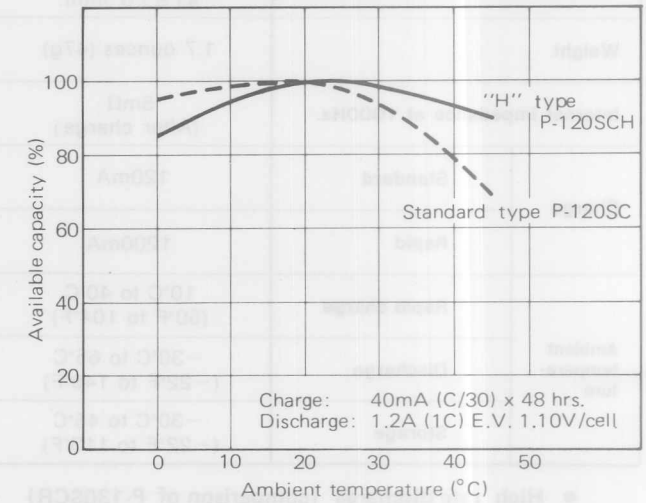
- **Trickle charge**



- **High rate discharge (Example)**



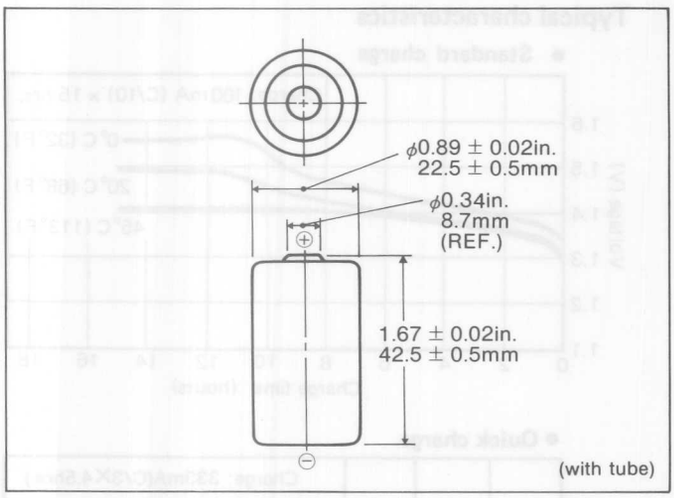
- **Comparison high temperature "H" vs. standard**



P-150SCE

Type: High capacity "E"
Size: SC

1500mAh



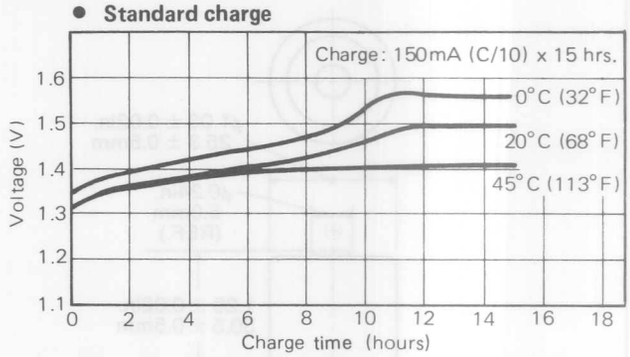
Specifications

Nominal voltage			1.2V		
Capacity (mAh)			C/10	C/5	C
	Nominal		1550	**1500**	1250
	Typical		1650	1600	1550
Diameter			0.89 ± 0.02in. 22.5 ± 0.5mm		
Height			1.67 ± 0.02in. 42.5 ± 0.5mm		
Weight			1.8 ounces (51g)		
Internal impedance at 1000Hz.			13mΩ (After charge)		
Charge	**Standard**		150mA × 15h		
	Quick		—		
	Trickle	**Max.**	75mA		
		Min.	50mA		
Ambient temperature	**Charge**		0° to 45°C (32° to 113°F)		
	Disharge		−20° to 65°C (−4° to 149°F)		
	Storage		−20° to 45°C (−4° to 113°F)		

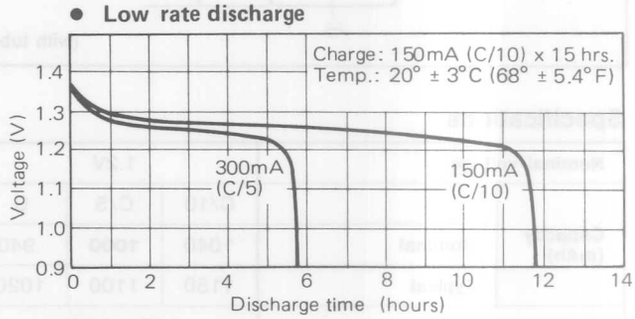
Note:
1. Nominal capacity, rated at C/5, 20°C
2. Other capacities are for reference.
3. See paragraph 1.6.2., for charging details.
4. Weight and internal impedance are for reference.
5. For bare cell, see page 75.

Typical characteristics

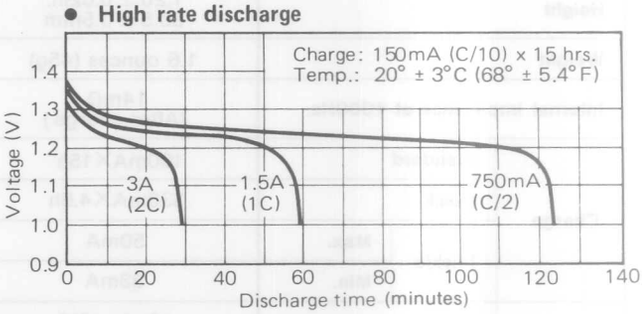
- **Standard charge**



- **Low rate discharge**



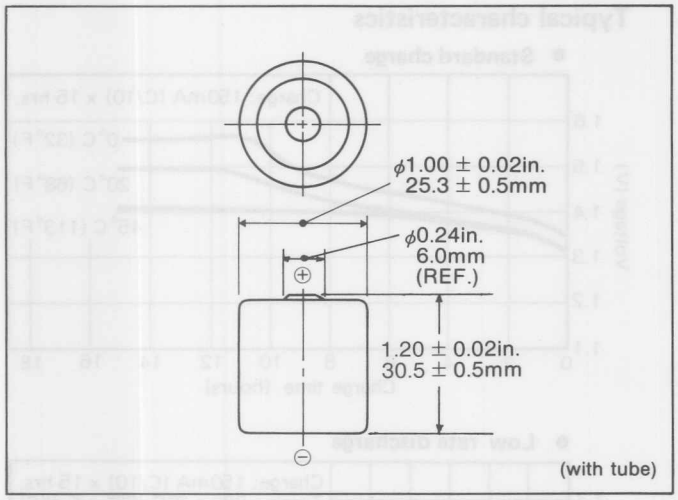
- **High rate discharge**



P-100C

Type: Standard
Size: 2/3 C

1000mAh



Specifications

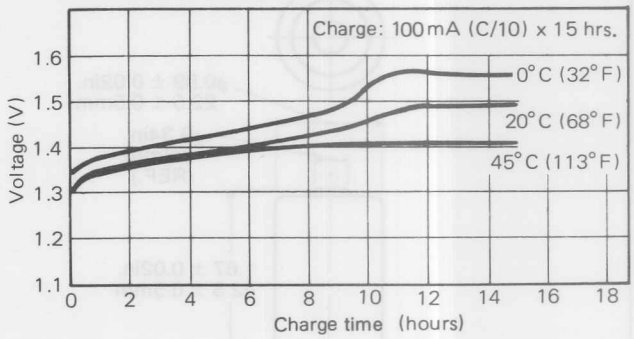
Nominal voltage			1.2V		
Capacity (mAh)			C/10	C/5	C
	Nominal		1040	**1000**	940
	Typical		1150	1100	1020
Diameter			1.00 ± 0.02in. 25.3 ± 0.5mm		
Height			1.20 ± 0.02in. 30.5 ± 0.5mm		
Weight			1.6 ounces (45g)		
Internal impedance at 1000Hz.			14mΩ (After charge)		
Charge	**Standard**		100mA×15h		
	Quick		333mA×4.5h		
	Trickle	**Max.**	50mA		
		Min.	33mA		
Ambient temperature	**Quick Charge**		10° to 45°C (50° to 113°F)		
	Standard and trickle		0° to 45°C (32° to 113°F)		
	Discharge		−20° to 65°C (−4° to 149°F)		
	Storage		−20° to 45°C (−4° to 113°F)		

Note:

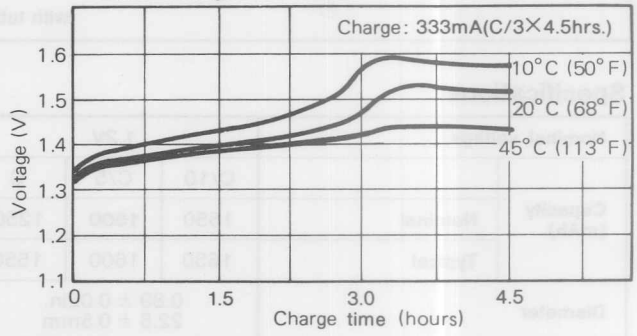
1. Nominal capacity, rated at C/5, 20°C
2. Other capacities are for reference.
3. See paragraph 1.6.2., for charging details.
4. Weight and internal impedance are for reference.
5. For bare cell, see page 75.

Typical characteristics

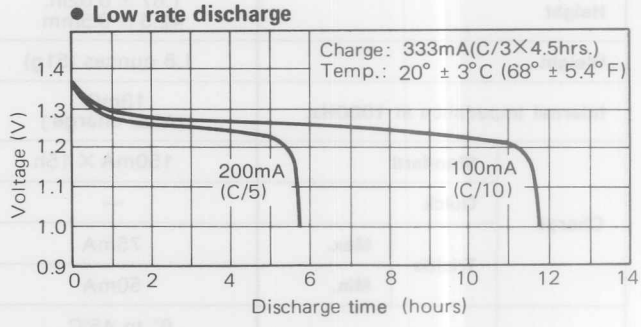
● **Standard charge**



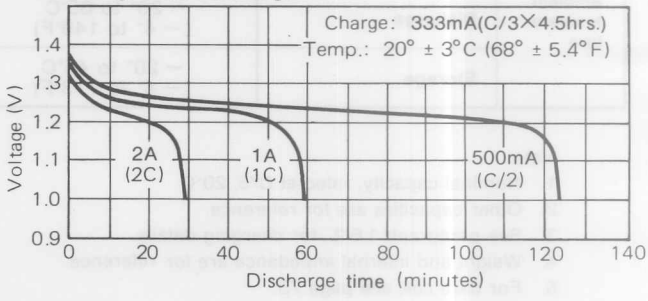
● **Quick charge**



● **Low rate discharge**



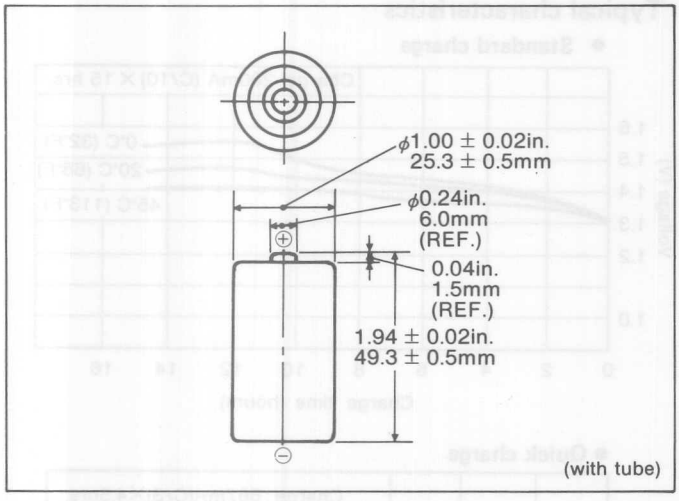
● **High rate discharge**



P-180C

Type: Standard
Size: C

1800mAh



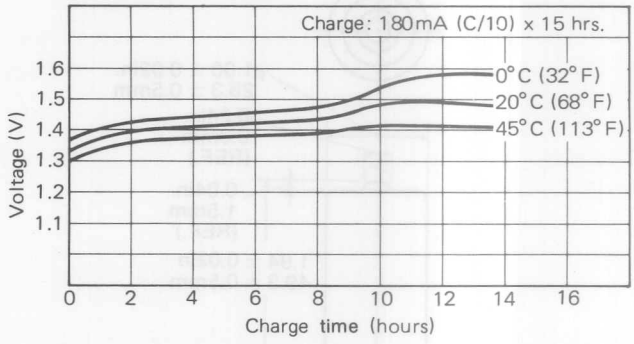
Specifications

Nominal voltage			1.2V		
Capacity (mAh)			C/10	C/5	C
	Nominal		1890	**1800**	1620
	Typical		2050	1950	1700
Diameter			1.00 ± 0.02in. 25.3 ± 0.5mm		
Height			1.94 ± 0.02in. 49.3 ± 0.5mm		
Weight			2.6 ounces (73g)		
Internal impedance at 1000Hz.			10mΩ (After charge)		
Charge	**Standard**		180mA×15h		
	Quick		—		
	Trickle	**Max.**	90mA		
		Min.	60mA		
Ambient temperature	**Charge**		0° to 45°C (32° to 113°F)		
	Disharge		−20° to 65°C (−4° to 149°F)		
	Storage		−20° to 45°C (−4° to 113°F)		

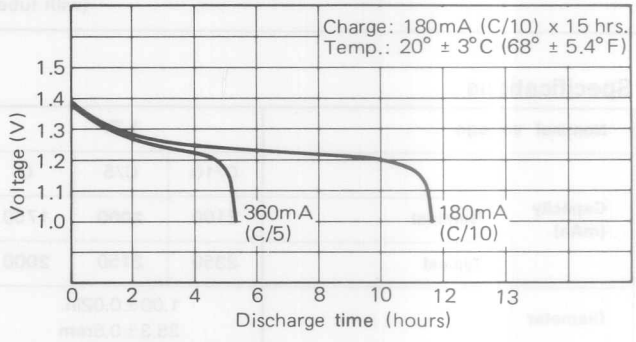
Note:
1. Nominal capacity, rated at C/5, 20°C
2. Other capacities are for reference.
3. See paragraph 1.6.2., for charging details.
4. Weight and internal impedance are for reference.
5. For bare cell, see page 75.

Typical characteristics

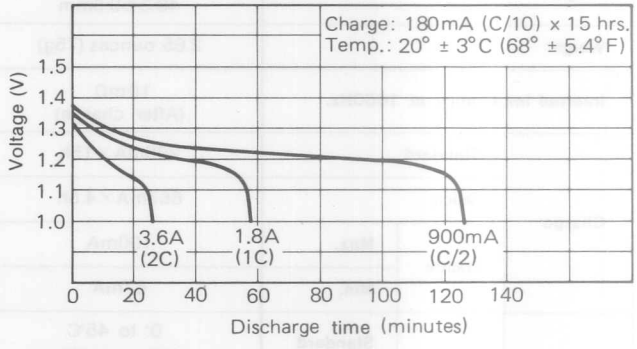
- **Standard charge**



- **Low rate discharge**



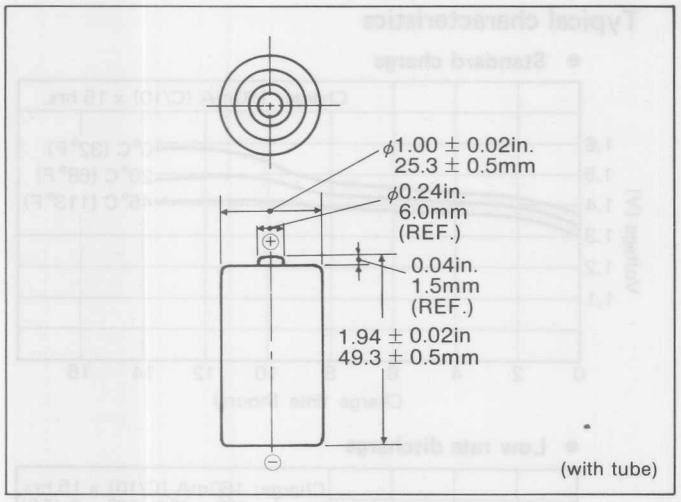
- **High rate discharge**



P-200C

Type: Standard
Size: C

2000mAh



Specifications

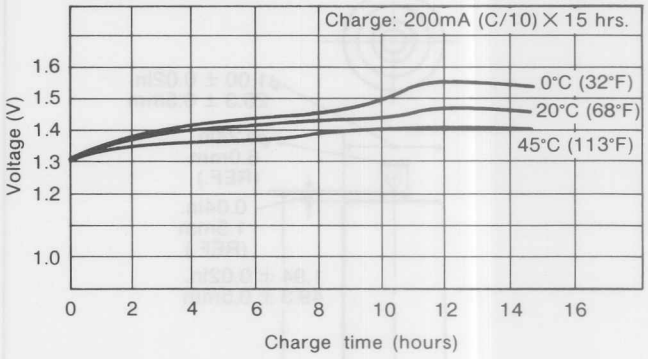
Nominal voltage			1.2V		
Capacity (mAh)			C/10	C/5	C
	Nominal		2100	**2000**	1750
	Typical		2350	2150	2000
Diameter			1.00±0.02in. 25.3±0.5mm		
Height			1.94±0.02in. 49.3±0.5mm		
Weight			2.65 ounces (75g)		
Internal impedance at 1000Hz.			10mΩ (After charge)		
Charge	Standard		200mA×15h		
	Quick		667mA×4.5h		
	Trickle	Max.	100mA		
		Min.	67mA		
Ambient temperature	Charge	Standard	0° to 45°C (32° to 113°F)		
		Quick	10° to 45°C (50° to 113°F)		
	Disharge		−20° to 65°C (−4° to 149°F)		
	Storage		−20° to 45°C (−4° to 113°F)		

Note:

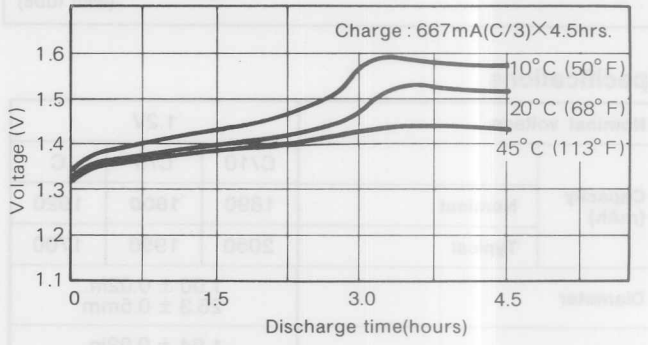
1. Nominal capacity, rated at C/5, 20°C
2. Other capacities are for reference.
3. See paragraph 1.6.2., for charging details.
4. Weight and internal impedance are for reference.
5. For bare cell, see page 75.

Typical characteristics

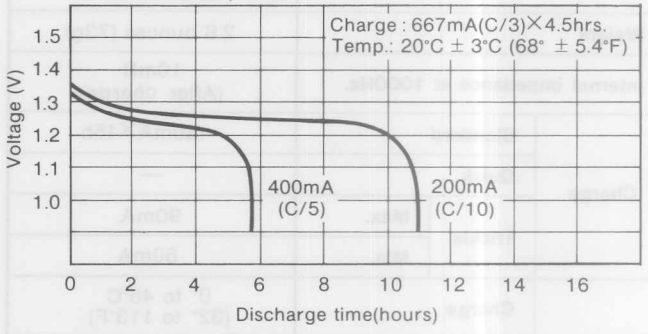
● **Standard charge**



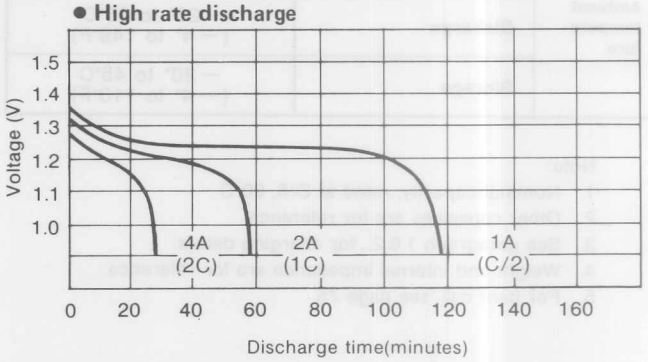
● **Quick charge**



● **Low rate discharge**



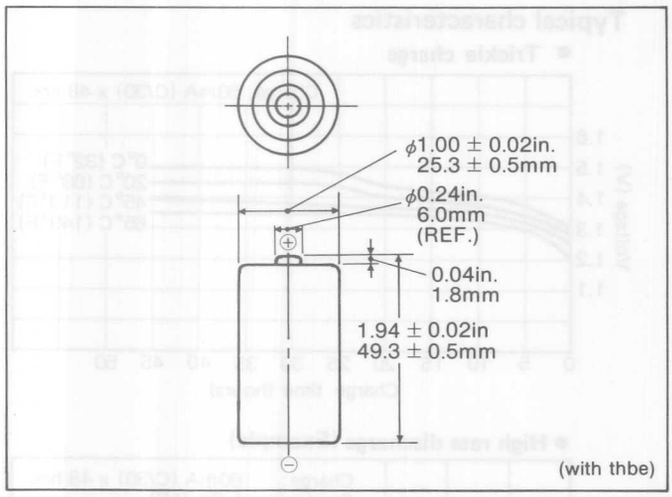
● **High rate discharge**



P-180CR

Type: Rapid Charge "R"
Size: C

1650mAh



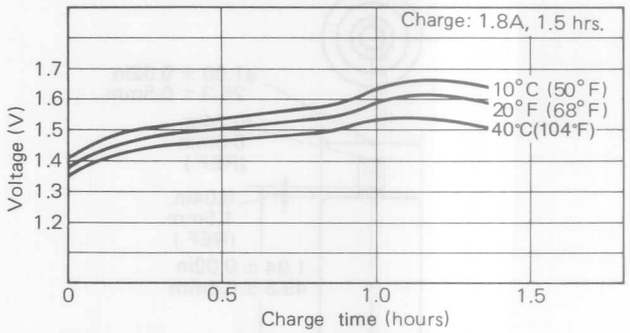
Specifcations

Nominal voltage		1.2V		
Capacity (mAh)		C/10	C/5	C
	Nominal	1700	**1650**	1485
	Typical	1950	1800	1620
Diameter		1.00 ± 0.02in. 25.3 ± 0.5mm		
Height		1.94 ± 0.02in. 49.3 ± 0.5mm		
Weight		2.5 ounces (71g)		
Internal impedance at 1000Hz.		12mΩ (After charge)		
Charge	**Standard**	180mA×15h		
	Rapid	1800mA×1.5h		
	Trickle	—		
Ambient temperature	**Rapid charge**	10° to 40°C (50° to 104°F)		
	Discharge	−20° to 65°C (−4° to 149°F)		
	Storage	−20° to 45°C (−4° to 113°F)		

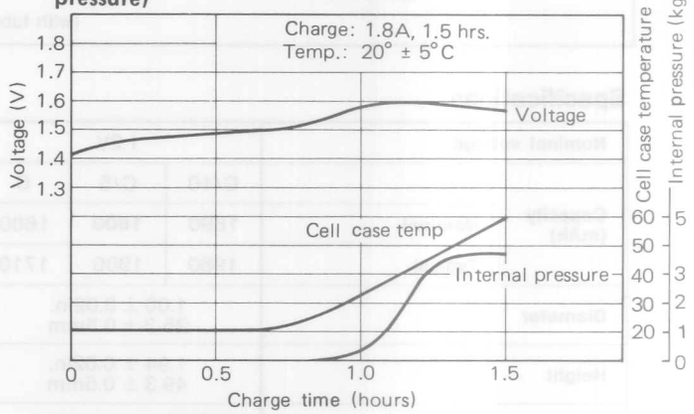
Note:
1. Nominal capacity, rated at C/5, 20°C
2. Other capacities are for reference.
3. See paragraph 1.6.2., for charging details.
4. Weight and internal impedance are for reference.
5. For bare cell, see page 75.

Typical characteristics

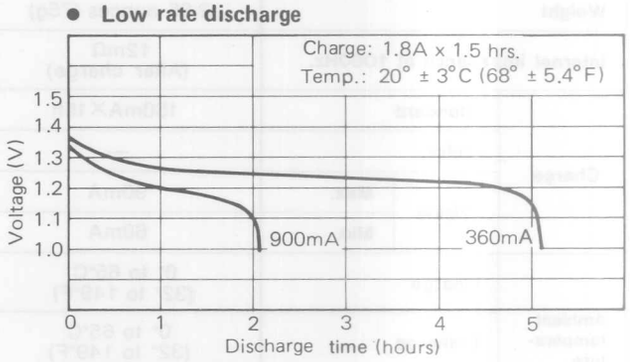
- **Rapid charge (Temperature)**



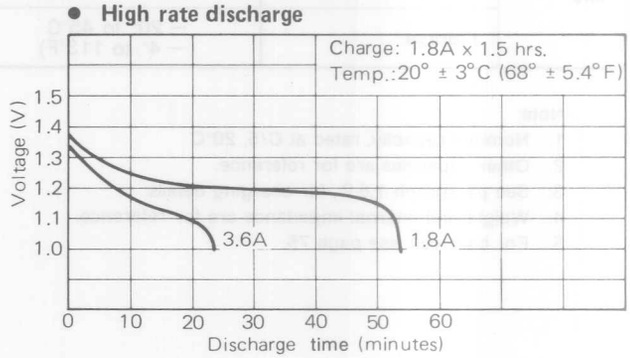
- **Rapid charge (voltage, cell case temperature, internal pressure)**



- **Low rate discharge**



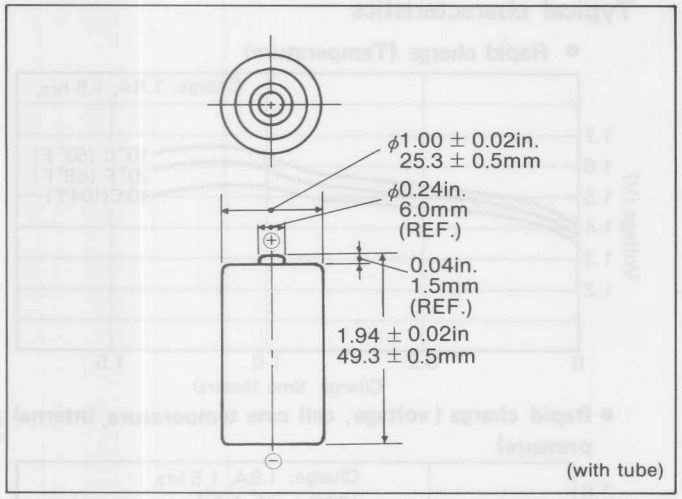
- **High rate discharge**



P-180CH

Type: High Temp. "H"
Size: C

1800mAh



Specifications

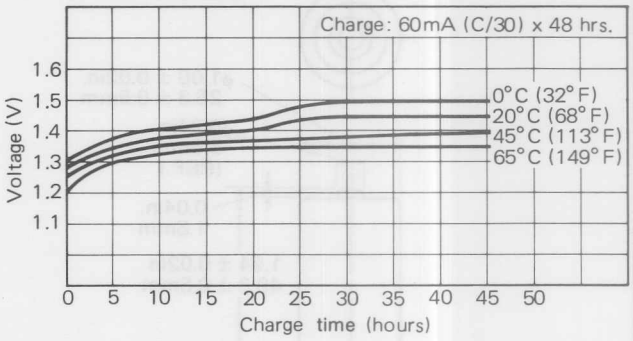
Nominal voltage			1.2V		
Capacity (mAh)			C/10	C/5	C
	Nominal		1890	**1800**	1600
	Typical		1980	1900	1710
Diameter			1.00 ± 0.02in. 25.3 ± 0.5mm		
Height			1.94 ± 0.02in. 49.3 ± 0.5mm		
Weight			2.65 ounces (75g)		
Internal impedance at 1000Hz.			12mΩ (After charge)		
Charge	**Standard**		180mA×15h		
	Quick		—		
	Trickle	**Max.**	90mA		
		Min.	60mA		
Ambient temperature	**Charge**		0° to 65°C (32° to 149°F)		
	Disharge		0° to 65°C (32° to 149°F)		
	Storage		−20° to 45°C (−4° to 113°F)		

Note:

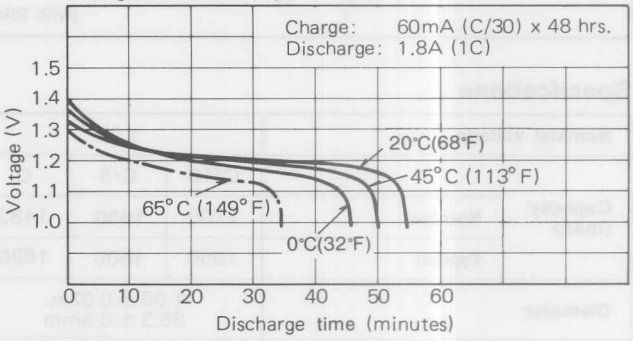
1. Nominal capacity, rated at C/5, 20°C
2. Other capacities are for reference.
3. See paragraph 1.6.2., for charging details.
4. Weight and internal impedance are for reference.
5. For bare cell, see page 75.

Typical characteristics

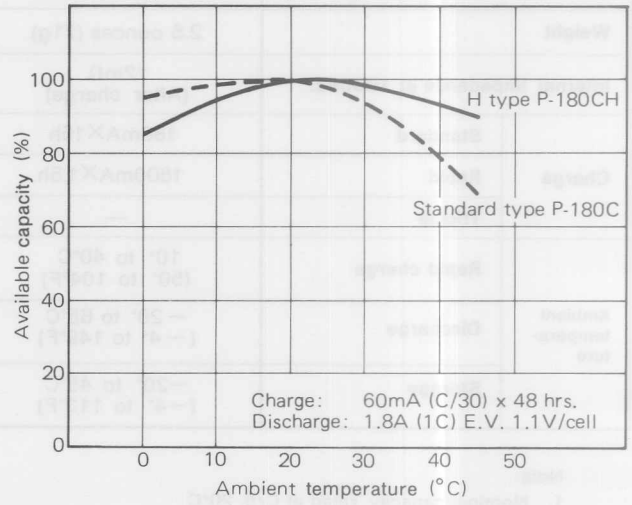
● **Trickle charge**



● **High rate discharge (Example)**



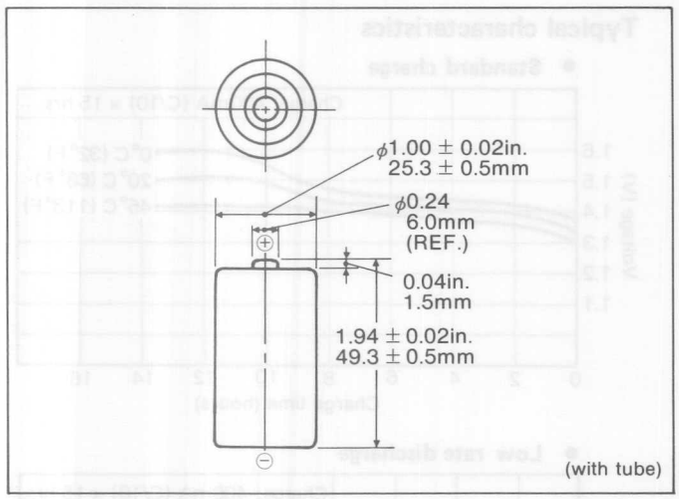
● **Comparison of high temperature "H" vs. standard**



P-220CE

Type: High Capacity "E"
Size: C

2000mAh



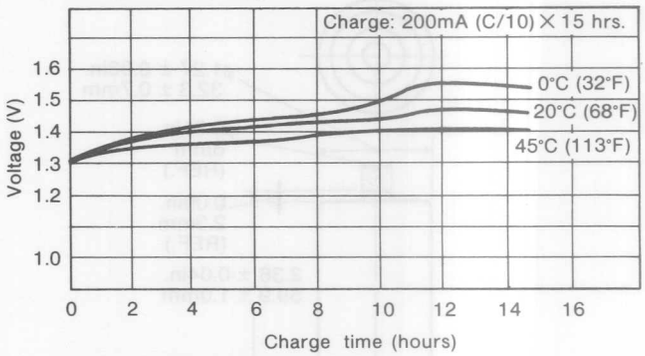
Specifications

Nominal voltage			1.2V		
Capacity (mAh)			C/10	C/5	C
	Nominal		2100	**2000**	1700
	Typical		2350	2300	2000
Diameter			1.00 ± 0.02in. 25.3 ± 0.5mm		
Height			1.94 ± 0.02in. 49.3 ± 0.5mm		
Weight			2.65 ounces (75g)		
Internal impedance at 1000Hz.			8mΩ (After charge)		
Charge	**Standard**		200mA×15h		
	Quick		—		
	Trickle	**Max.**	100mA		
		Min.	67mA		
Ambient temperature	**Charge**		0° to 45°C (32° to 113°F)		
	Disharge		−20° to 65°C (−4° to 149°F)		
	Storage		−20° to 45°C (−4° to 113°F)		

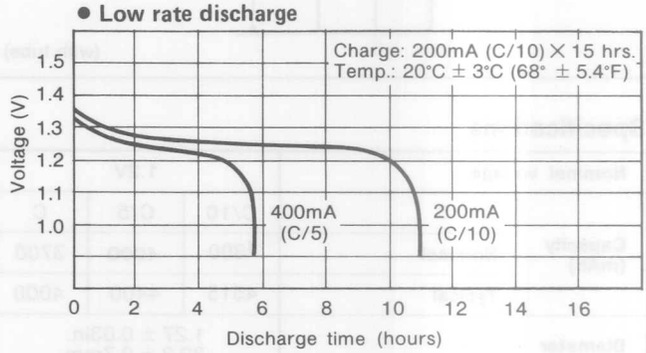
Note:
1. Nominal capacity, rated at C/5, 20°C
2. Other capacities are for reference.
3. See paragraph 1.6.2., for charging details.
4. Weight and internal impedance are for reference.
5. For bare cell, see page 75.

Typical characteristics

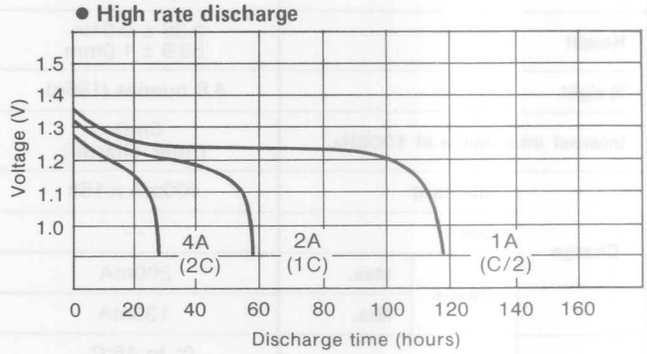
● **Standard charge**



● **Low rate discharge**



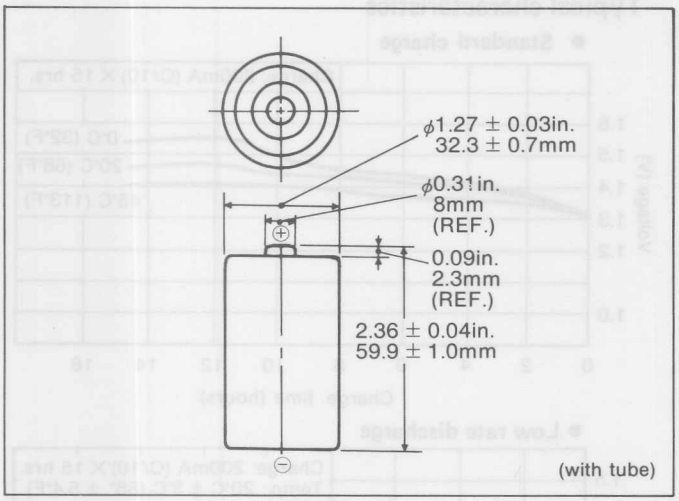
● **High rate discharge**



P-400D

Type: Standard
Size: D

4000mAh



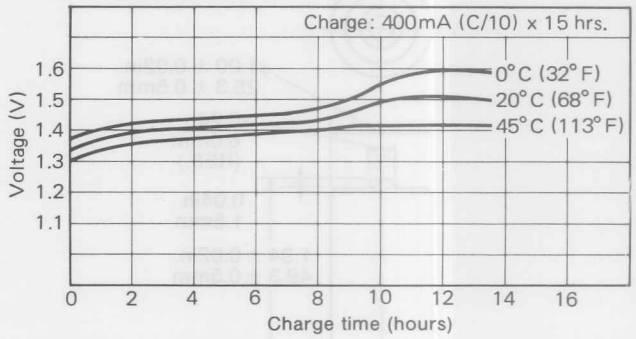
Specifications

Nominal voltage			1.2V		
Capacity (mAh)			C/10	C/5	C
	Nominal		4300	**4000**	3700
	Typical		4515	4400	4000
Diameter			1.27 ± 0.03in. 32.3 ± 0.7mm		
Height			2.36 ± 0.04in. 59.9 ± 1.0mm		
Weight			4.8 ounces (136g)		
Internal impedance at 1000Hz.			8mΩ (After charge)		
Charge	**Standard**		400mA×15h		
	Quick		—		
	Trickle	**Max.**	200mA		
		Min.	133mA		
Ambient temperature	**Charge**		0° to 45°C (32° to 113°F)		
	Discharge		−20° to 65°C (−4° to 149°F)		
	Storage		−20° to 45°C (−4° to 113°F)		

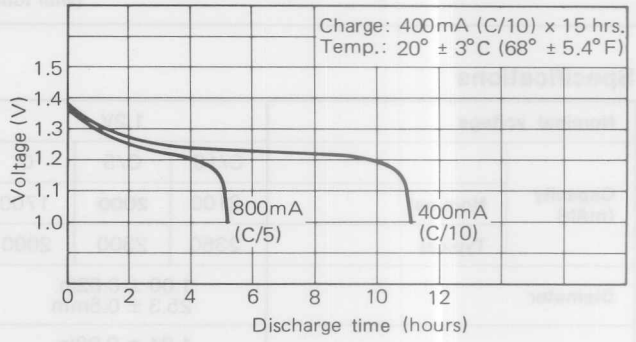
Note:
1. Nominal capacity, rated at C/5, 20°C
2. Other capacities are for reference.
3. See paragraph 1.6.2., for charging details.
4. Weight and internal impedance are for reference.
5. For bare cell, see page 75.

Typical characteristics

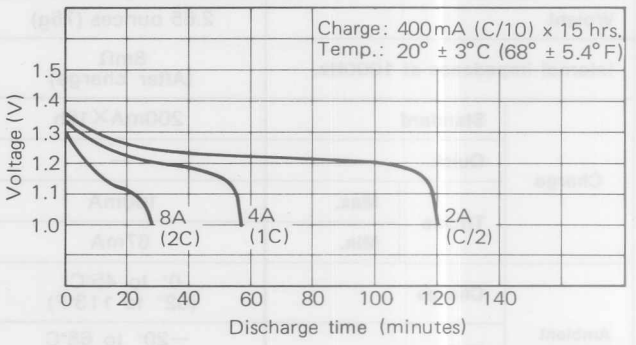
- **Standard charge**



- **Low rate discharge**



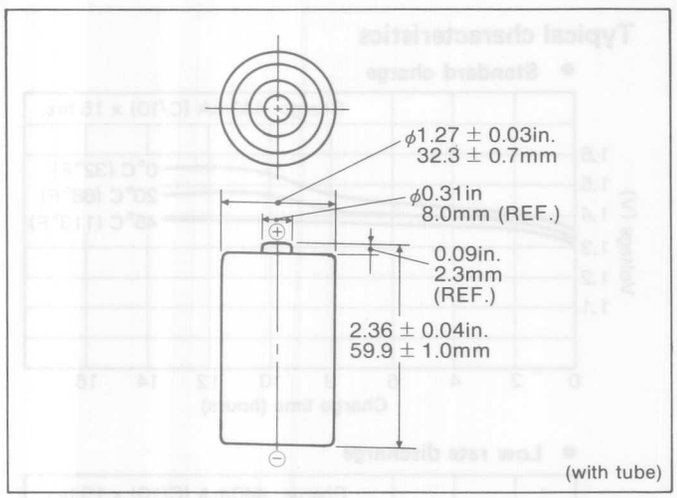
- **High rate discharge**



P-400DH

Type: High temp. "H"
Size: D

4000mAh



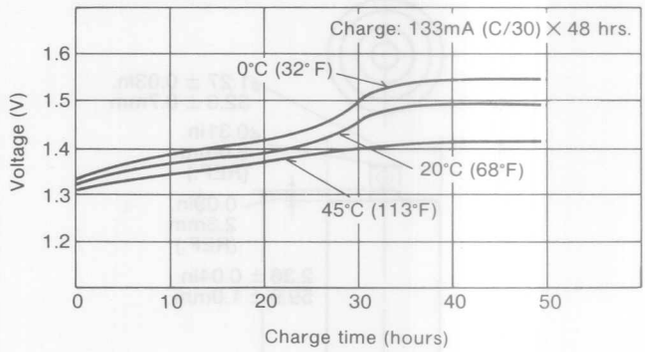
Specifications

Nominal voltage			1.2V		
Capacity (mAh)			C/10	C/5	C
	Nominal		4200	**4000**	3600
	Typical		4400	4200	3900
Diameter			1.27 ± 0.03in. 32.3 ± 0.7mm		
Height			2.36 ± 0.04in. 59.9 ± 1.0mm		
Weight			4.9 ounces (140g)		
Internal impedance at 1000Hz.			8mΩ (After charge)		
Charge	**Standard**		400mA×15h		
	Quick		—		
	Trickle	**Max.**	200mA		
		Min.	133mA		
Ambient temperature	**Charge**		0° to 65°C (32° to 149°F)		
	Discharge		0° to 65°C (32° to 149°F)		
	Storage		−20° to 45°C (−4° to 113°F)		

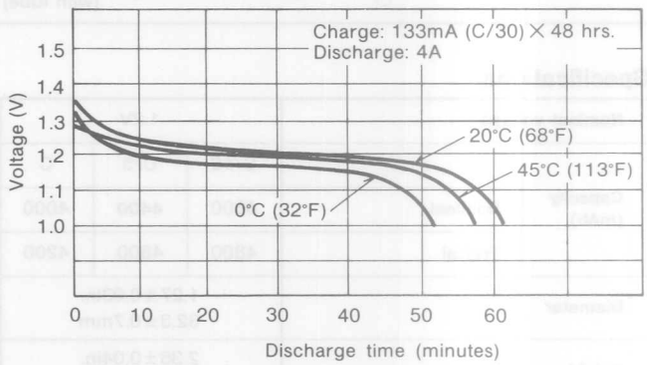
Note:
1. Nominal capacity, rated at C/5, 20°C
2. Other capacities are for reference.
3. See paragraph 1.6.2., for charging details.
4. Weight and internal impedance are for reference.
5. For bare cell, see page 75.

Typical characteristics

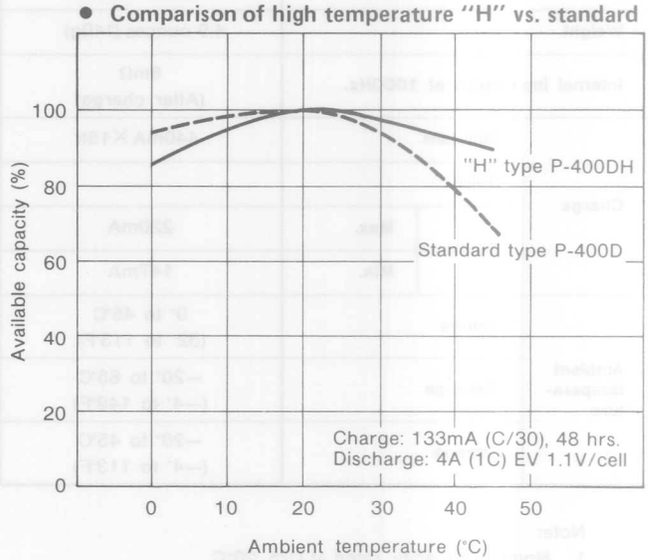
- **Trickle charge**



- **High rate discharge**



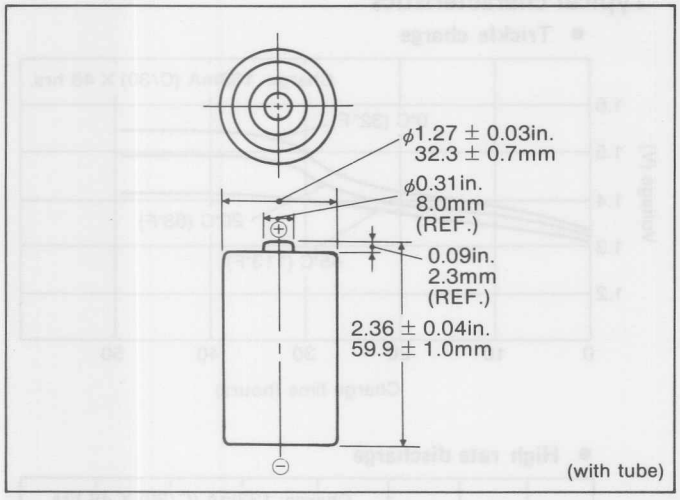
- **Comparison of high temperature "H" vs. standard**



P-440DE

Type: High capacity "E"
Size: D

4400mAh



Specifications

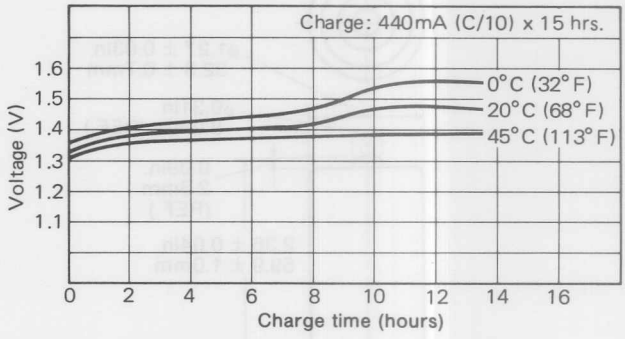
Nominal voltage			1.2V		
Capacity (mAh)			C/10	C/5	C
	Nominal		4600	**4400**	4000
	Typical		4800	4800	4200
Diameter			1.27±0.03in. 32.3±0.7mm		
Height			2.36±0.04in. 59.9±1.0mm		
Weight			4.9 ounces (140g)		
Internal impedance at 1000Hz.			8mΩ (After charge)		
Charge	**Standard**		440mA×15h		
	Quick		—		
	Trickle	**Max.**	220mA		
		Min.	147mA		
Ambient temperature	**Charge**		0° to 45°C (32° to 113°F)		
	Disharge		−20° to 65°C (−4° to 149°F)		
	Storage		−20° to 45°C (−4° to 113°F)		

Note:

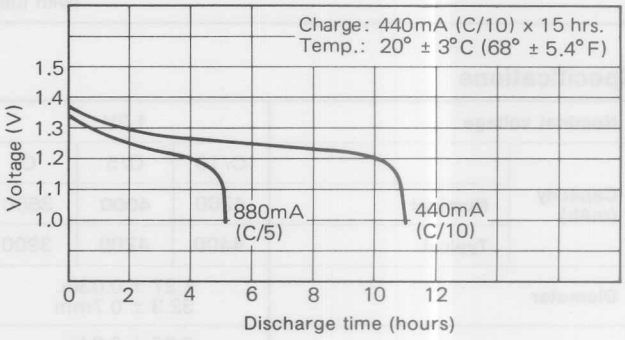
1. Nominal capacity, rated at C/5, 20°C
2. Other capacities are for reference.
3. See paragraph 1.6.2., for charging details.
4. Weight and internal impedance are for reference.
5. For bare cell, see page 75.

Typical characteristics

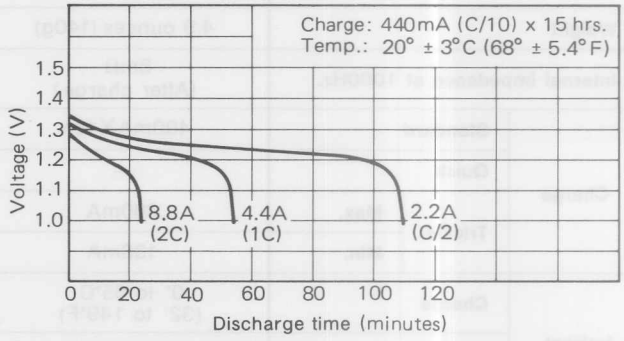
- **Standard charge**



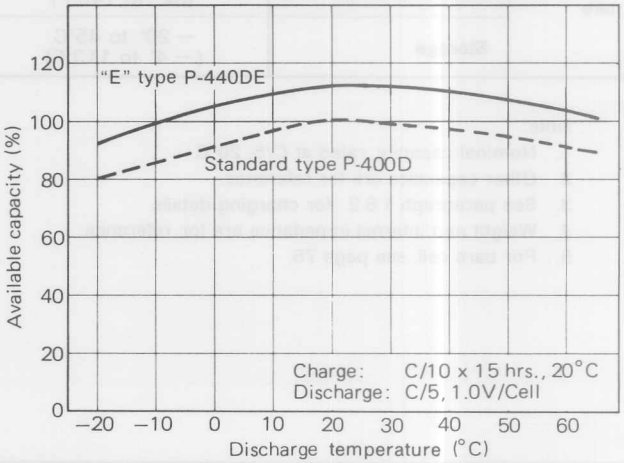
- **Low rate discharge**



- **High rate discharge**

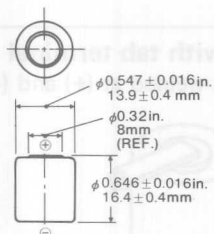


- **Comparison of high capacity vs. standard**

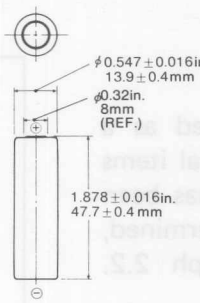


5. Bare Cell Dimensions

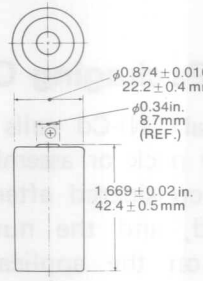
P-11AA
P-11AAH



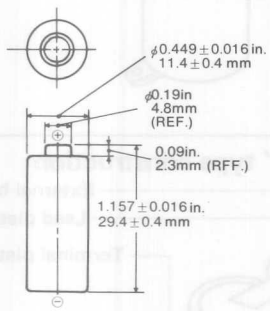
P-50AA/FT
P-50AAR
P-50AAH
P-60AAE



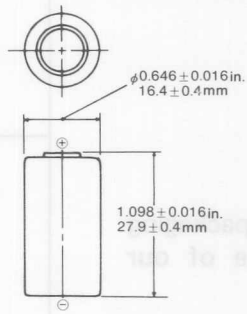
P-130SCR
P-120SCRP
P-150SCE
P-120SCH



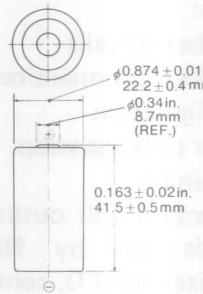
P-15N



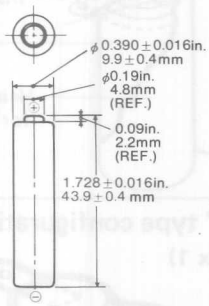
P-40AR



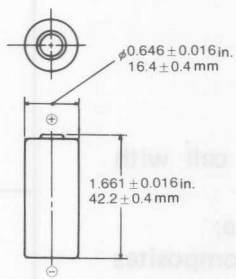
P-130SCRC
P-120SCPC



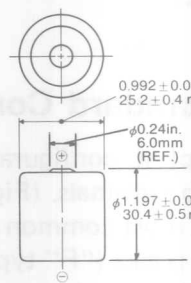
P-18AAA



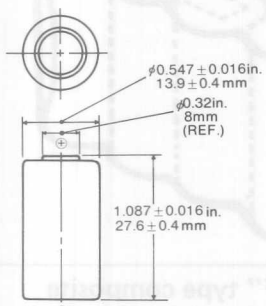
P-70AR



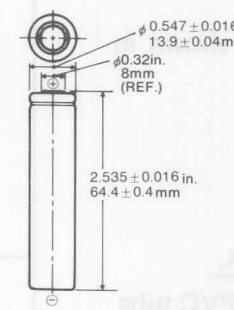
P-100C



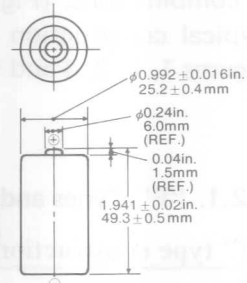
P-25AA



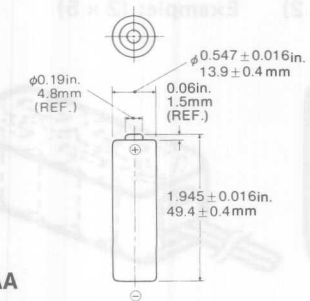
P-80AAR
P-100AAS



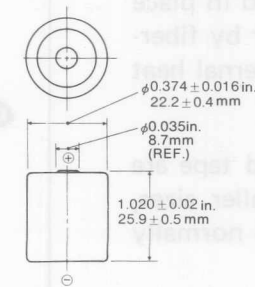
P-180C/180CR
P-200C/180CH
P-220CE



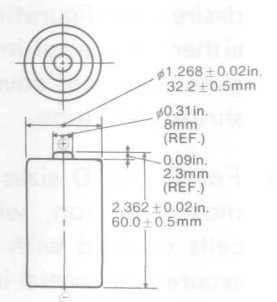
P-50AA



P-60SC



P-400D
P-400DH
P-440DE



6. Battery Packs

6.1. Packaging Considerations

National Ni-Cd cells are frequently used as a battery pack or assembly. There are several items to be considered after the correct cell has been selected, and the number of cells determined, based on the application. (See paragraph 2.2. Battery Design Guide. page 24)

When planning a battery pack, key considerations include:

- number of cells
- intercell connnections
- configuration
- outer package wrap
- terminals

This section will outline some standard packaging methods used by National, and some of our authorized M.O.D. centers.

For detailed packaging assistance, please contact National .

6.2. Standard Configurations

The simplest configuration is a single cell with solder tab terminals. (Fig. 1)

The next most common configurations are;

- In-line packs ("F" type) (Fig. 2) and composites (Fig. 3)
- Cylindrical Stacks ("L" type) (Fig. 4) and combinations. (Fig. 5)

Typical construction of these packs are shown in Figures 1, 2, 3, 4 and 5, or A and B.

6.2.1. "F" Types and Composites

"F" type construction is shown in Fig. 1A.

(A) Cells are insulated with heat shrink PVC tube or kraft paper, and then assembled into the desired configuration. Cells are held in place either by special instant adhesive or by fiber-glass tape, and covered with an external heat shrink PVC tube.

(B) For C and D sizes, kraft tubes and tape are most common, while for the smaller sizes, cells covered with a PVC tube are normally secured by special instant adhesive.

Fig. 1 Single cell with tab terminal
A tab terminal is spot-welded at (+) and (—) poles.

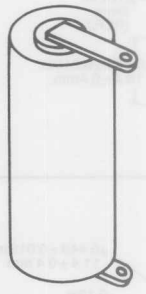


Fig. 1A. "F" type construction

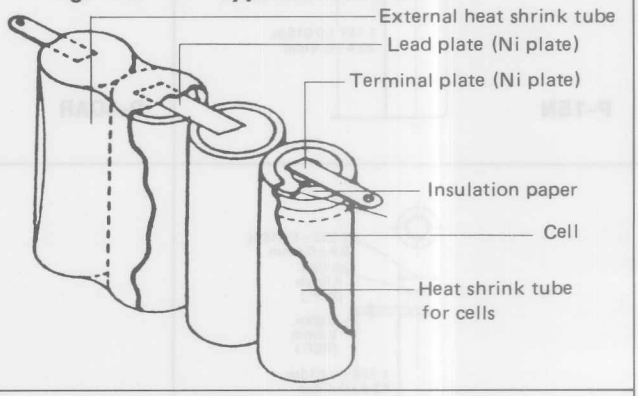


Fig. 2. "F" type configuration
Example: (4 x 1)

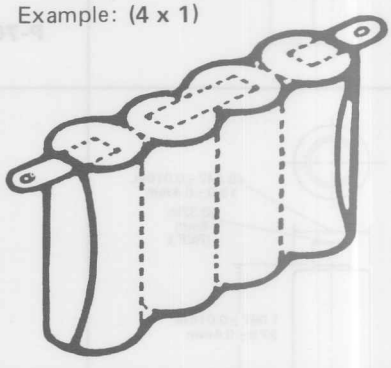
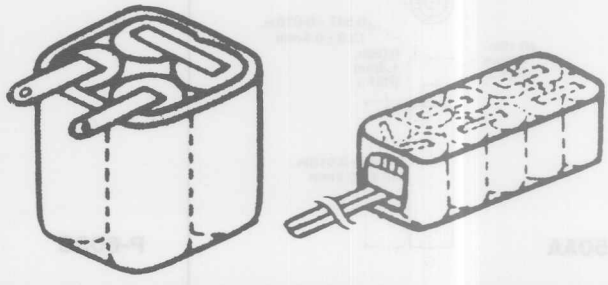


Fig. 3. "F" type composite
Single cells are connected in 2 to 5 rows and packed in a heat-shrinkable tube.
Example: (2 x 2) **Example: (2 x 5)**



(C) Typical "F" type configurations: (Fig. 2)

"F"	Volts	Cells	Configurations
2 x 1	2.4	2	
3 x 1	3.6	3	
4 x 1	4.8	4	
5 x 1	6.0	5	
6 x 1	7.2	6	
7 x 1	8.4	7	
8 x 1	9.6	8	
9 x 1	10.8	9	
10 x 1	12.0	10	

(D) "F" type composites: (Fig. 3)

"F" composites	Volts	Cells	Configurations
2 x 2	4.8	4	
2 x 3	7.2	6	
2 x 4	9.6	8	
2 x 5	12.0	10	

6.2.2. "L" Types and Combinations

"L" type construction is shown in Fig. B.

(A) "L" type cylindrical stacks are available in several typical configurations and combinations.

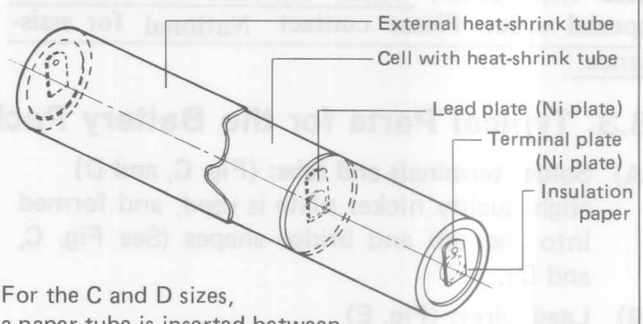
(B) Typical "L" type configurations: (Fig. 4)

"L"	Volts	Cells	Configurations
2 x 1	2.4	2	
3 x 1	3.4	3	
4 x 1	4.8	4	
5 x 1	6.0	5	

(C) Typical "L" type combinations: (Fig. 5)

"L" combinations	Volts	Cells	Configurations
2 x 2	4.8	4	
3 x 2	7.2	6	
4 x 2	9.6	8	
5 x 2	12.0	10	
2 x 3	7.2	6	
2 x 4	9.6	8	
2 x 5	12.0	10	

Fig. B. "L" type construction



For the C and D sizes, a paper tube is inserted between the battery and the external heat-shrink tube.

Fig. 4. "L" type configuration
Example: (3 x 1)

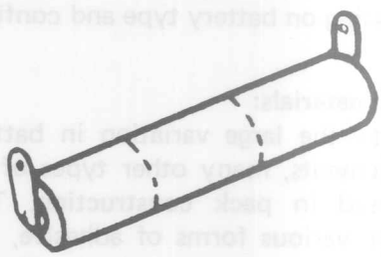
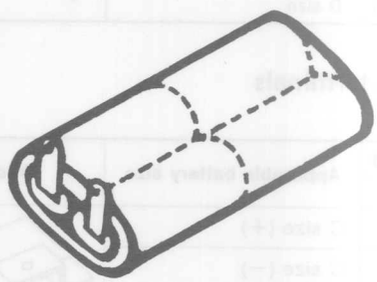


Fig. 5. "L" type combination
Single cells are connected in 2 to 6 rows and packed in a heat-shrink PVC tube.
Example: (2 x 2)



6.2.3. Batteries in Injection-molded plastic case

Batteries are packed in an injection-molded outer case with cover. These batteries are made on special order. Please contact National for assistance.

6.3. Typical Parts for the Battery Pack

(A) Solder terminals and tabs: (Fig. C, and D)
High quality nickel plate is used, and formed into the tab and bridge shapes (See Fig. C, and D).

(B) Lead wires: (Fig. E)
Lead wires for battery packs usually use heat-resistant vinyl wire conforming to UL1007. Normal color coding is red (+), and black (−). The ends of the wires can be supplied precut, pretinned, or with attached terminals. Details are arranged when ordering.

(C) Heat-shrink tube
Heat-shrink tubes made of polyvinylchloride are used on many packs as the external cover. Tube thickness ranges from 0.1mm to 0.2mm depending on battery type and configuration.

(D) Other materials:
Due to the large variation in battery pack requirements, many other types of materials are used in pack construction. This may include various forms of adhesive, insulating material, temperature sensors, thermal protectors and diodes. For assistance with a specific application, contact National

Fig. C. Standard solder tabs/terminals

Material: nickel

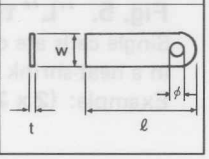
Dimensions (mm)				Applicable battery size	Tab
ϕ	t	W	L		
1.5	0.15	4	15	AA size or smaller	
2	0.15	5	20	SC size	
2	0.15	5	12	C size	
2	0.15	7	15	D size	

Fig. D. Bridge terminals

t = 0.15 mm

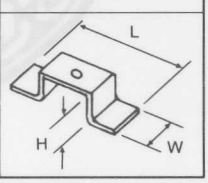
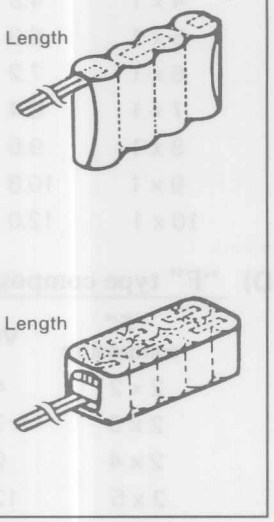
Dimensions (mm)			Applicable battery size	Bridge
W	H	L		
5	3	11	C size (+)	
5	1.3	11	C size (−)	
7	4.2	15.5	D size (+)	
7	1.3	15.5	D size (−)	

Fig. E. Standard lead wires

Cell Size	Size	Length (mm)	Color	Configurations
1/3 AA	UL1007 AWG 24	200	(+) red (−) black	
N	UL1007 AWG 24	200	(+) red (−) black	
AAA	UL1007 AGW 24	200	(+) red (−) black	
2/3 AA	UL1007 AWG 24	200	(+) red (−) black	
AA	UL1007 AWG 24	200	(+) red (−) black	
2/3 SC	UL1007 AGW 24	200	(+) red (−) black	
SC	UL1007 AWG 20	200	(+) red (−) black	
C	UL1007 AWG 20	300	(+) red (−) black	
D	UL1007 AWG 18	300	(+) red (−) black	

Note: other wires available on special order

6.4. Inspection of Battery Packs

National batteries are subjected to a 100% appearance check and voltage test before shipment.

(A) Appearance check
The following items are checked: scarred or dirty exterior, labeling and external dimensions.

(B) Closed circuit voltage test
Charged batteries are discharged for a brief time with a resistance load at approximately 1C. The battery voltage is measured during discharge to be sure that it has a voltage of 1.2V/cell or more.

(C) Open circuit voltage
For discharged batteries, open circuit voltage is measured to be sure that it is 1.0V/cell or more.

7. Cross Reference Guide

Dimensions of Sealed Nickel-Cadmium Batteries to International Standards

National			IEC (International Electro chemical Commission)			ANSI (American Standards Institate)			DIN (Deutsche Industrie-Norm)			JIS (Japanes Industrial Standard)			Dry Cell (Reference)		
Model	Dimensions		Model	Dimensions		Model	Dimensions		Model	Dimensions		Model	Dimensions		Model	Dimensions	
	Diameter	Height		Diameter	Height		Diameter	Height		Diameter	Height		Diameter	Height		Diameter	Height
P-11AA	14.0±0.5	16.5±0.5	KR15/18	14.5 $^{0}_{-1.5}$	18.0 $^{0}_{-2.0}$							KR-1/3AA	14.5 $^{0}_{-1.0}$	17.0 $^{0}_{-1.0}$			
P-15N	11.5±0.5	29.5±0.5	KR12/30	12.0 $^{0}_{-1.5}$	30.0 $^{0}_{-2.0}$							KR-N	12.0 $^{0}_{-1.0}$	30.0 $^{0}_{-1.0}$			
P-18AAA	10.0±0.5	44.0±0.5	KR11/45	10.5 $^{0}_{-1.5}$	44.5 $^{0}_{-1.5}$							KR-AAA	10.5 $^{0}_{-1.0}$	44.5 $^{0}_{-1.5}$	UM-4	10.5 $^{0}_{-1.0}$	44.5 $^{0}_{-1.5}$
P-25AA	14.0±0.5	27.7±0.5	KR15/29	14.5 $^{0}_{-1.5}$	29.0 $^{0}_{-2.0}$	K30	14.3	27.8				KR-2/3AA	14.5 $^{0}_{-1.0}$	30.0 $^{0}_{-1.0}$			
P-40AR	16.5±0.5	28.0±0.5	KR18/29	17.5 $^{0}_{-1.5}$	28.5 $^{0}_{-2.0}$							KR-2/3AA	17.0 $^{0}_{-1.0}$	28.5 $^{0}_{-2.0}$			
P-50AA	14.0±0.5	49.5±0.5	KR15/51	14.5 $^{0}_{-1.5}$	50.5 $^{0}_{-2.0}$	K40	14.3	50.0	GSZ0.5	14.5 $^{0}_{-1.0}$	50.5 $^{0}_{-1.0}$	KR-AA	14.5 $^{0}_{-1.0}$	50.5 $^{0}_{-1.5}$	SUM-3 (UM-3)	14.5 $^{0}_{-1.0}$	50.5 $^{0}_{-1.5}$
P-60AAE	14.0±0.5	47.8±0.5	KR15/51	14.5 $^{0}_{-1.5}$	50.5 $^{0}_{-2.0}$												
P-60SC	22.5±0.5	26.0±0.5	KR23/27	23.0 $^{0}_{-1.5}$	26.4 $^{0}_{-2.0}$							KR-2/3SC	23.0 $^{0}_{-1.0}$	26.5 $^{0}_{-1.5}$			
P-70AR	16.5±0.5	42.5±0.5															
P-80AAR	14.0±0.5	64.5±0.5															
P-100AAS	14.0±0.5	64.5±0.5															
P-100C	25.3±0.5	30.5±0.5	KR27/33	26.2 $^{0}_{-1.5}$	32.8 $^{0}_{-2.0}$	K72	26.2	29.4				KR-2/3C	26.0 $^{0}_{-1.0}$	31.0 $^{0}_{-2.0}$			
P-130SCR	22.5±0.5	42.5±0.5	KR23/43	23.0 $^{0}_{-1.5}$	42.8 $^{0}_{-2.0}$	K60	22.9	42.8	GSZ1.2	23.5 $^{0}_{-1.0}$	42.6 $^{0}_{-1.0}$	KR-SC	23.0 $^{0}_{-1.0}$	43.0 $^{0}_{-2.0}$			
P-150SCE	22.5±0.5	42.5±0.5	KR23/43	23.0 $^{0}_{-1.5}$	42.8 $^{0}_{-2.0}$	K60	22.9	42.8	GSZ1.2	23.5 $^{0}_{-1.0}$	42.6 $^{0}_{-1.0}$	KR-SC	23.0 $^{0}_{-1.0}$	43.0 $^{0}_{-2.0}$			
P-180C	25.3±0.5	49.3±0.7	KR27/50	26.2 $^{0}_{-1.5}$	50.0 $^{0}_{-2.0}$	K70	26.2	50	GSZ1.8	25.5 $^{0}_{-1.0}$	49.0 $^{0}_{-1.0}$	KR-C	26.0 $^{0}_{-1.0}$	50.0 $^{0}_{-2.0}$	SUM-2 (UM-2)	26.0 $^{0}_{-1.0}$	50.0 $^{0}_{-2.0}$
P-220CE	25.3±0.5	49.3±0.7	KR27/50	26.2 $^{0}_{-1.5}$	50.0 $^{0}_{-2.0}$	K70	26.2	50	GSZ1.8	25.5 $^{0}_{-1.0}$	49.0 $^{0}_{-1.0}$	KR-C	26.0 $^{0}_{-1.0}$	50.0 $^{0}_{-2.0}$	SUM-2 (UM-2)	26.0 $^{0}_{-1.0}$	50.0 $^{0}_{-2.0}$
P-400D	32.3±0.7	59.9±1.0	KR35/62	34.2 $^{0}_{-2.0}$	61.5 $^{0}_{-2.0}$	K90	34.1	61.1	GSZ4	33.5 $^{0}_{-1.0}$	61.0 $^{0}_{-1.0}$	KR-D	34.0 $^{0}_{-2.0}$	61.5 $^{0}_{-2.5}$	SUM-1 (UM-1)	34.0 $^{0}_{-2.0}$	61.5 $^{0}_{-2.5}$
P-440DE	32.3±0.7	59.9±1.0	KR35/62	34.2 $^{0}_{-2.0}$	61.5 $^{0}_{-2.0}$	K90	34.1	61.1	GSZ4	33.5 $^{0}_{-1.0}$	61.0 $^{0}_{-1.0}$	KR-D	34.0 $^{0}_{-2.0}$	61.5 $^{0}_{-2.5}$	SUM-1 (UM-1)	34.0 $^{0}_{-2.0}$	61.5 $^{0}_{-2.5}$

8. National Testing and Standards

8.1. Capacity

Capacity shall meet or exceed the specified minimum using the following test method:

(A) Ambient temperature is 20°±3°C (68±5.4°F).
(B) Charge time is 15 hours at C/10.
(C) Discharge current is C/5, and end voltage shall be 1.0 Volt/cell.

8.2. Overcharge Limitation

The battery shall not be externally deformed, and the open circuit voltage shall be more than 1.3 Volt/cell, when the battery is overcharged at C/10 for 48 hours, and at ambient temperature 0 ~ 45°C (32 ~ 115°F).

8.3. Overdischarge

The battery shall not be externally deformed when the battery is overdischarged with a constant resistance load for 24 hours:

$$\text{The load } (\Omega) = \frac{1.2\text{V} \times \text{Number of cells}}{2 \times \text{C}} \times 1000$$

- For example: Cell type: P-50AA (500mAH)
  Volts: 6V (5 Cells)

$$\text{The load } (\Omega) = \frac{1.2 \times 5}{2 \times 500} \times 1000$$
$$= 6\Omega$$

8.4. Vibration

The battery shall be mechanically and electrically normal, after having been subjected to a vibration with an amplitude of 0.079 inches (2mm) and a frequency of 1,000 cycles/minutes, in the X, Y, and Z axis respectively, for 30 minutes.

8.5. Shock Test

The battery shall be mechanically and electrically normal after the following test:

(A) Drop the battery from a height of 20 cm on to hard wood which is at least 10 mm thick.
(B) The battery should be dropped so that it strikes its top, its bottom, and its side.

8.6. Humidity

The battery shall not leak electrolyte when it is subjected for 10 days to a temperature of 35°C (95°F) and a relative humidity of 85%.

8.7. Cycle Life

Cycle life shall be over 500 cycles via the following test method:

(A) Cycle condition: Discharge the cell for 2 hours at the C/4 rate, and charge for 6 hours at the C/8 rate.
(B) Capacity test: every 50 cycles, the cell is tested via the capacity test indicated in paragraph 8.1..
(C) Capacity shall be at or above 80% of rated capacity at 500 cycles.

8.8. Precautions

Charge

- **Charge current**

1. Do not charge batteries at any current greater than that specified.
2. Charging at a current greater than that specified causes the speed of gas absorption to exceed that of gas generation at the end of charge. This may raise the internal pressure of the battery, causing the safety valve to work.

- **Charge time**

1. Charge batteries only at the specified current and for the specified period.
2. Charging for longer than the specified period may result in deteriorated performance.

- **Charge temperature**

1. Charge batteries within the temperature range of 0°C to 45°C, as ambient temperatures can affect charge efficiency.
2. If a battery is charged at temperatures below 0°C, the speed of gas absorption decreases, causing internal pressure to rise, thus making the safety valve work.
   This may result in deteriorated performance and battery leakage.
3. Charging at temperatures above 45°C decreases charge efficiency and does not allow batteries to be fully charged. Deteriorated performance and battery leakage may result. (Except "H" type)

- **Reverse polarity charging**

1. Never attempt any reverse polarity charging.
2. Charging with polarity reversed may not only prevent battery charging but may also result in deteriorated performance and battery leakage. Make sure polarity is correct before charging.

- **Trickle charge (continuous charge)**

1. Use the current range of 1/30CmA to 1/20CmA for trickle charge.
2. Charging at currents below 1/30CmA may result in insufficient battery charging.

3. Charging at currents above 1/20CmA may cause overcharging, resulting in deteriorated performance and battery leakage.

- **Rapid charge**

1. To charge batteries rapidly, be sure to use a specified charger. Chargers are available according to the number and size of the batteries. Consult National about rapid chargers for exclusive use with the National batteries.

Discharge

- **Discharge current**

1. The discharge current should generally be below 2CmA except high rate type.
2. When discharged at currents above 2CmA, batteries may decrease markedly in capacity and become hot.

- **Discharge temperature**

1. Discharge batteries within the temperature range of −20°C to 65°C.
2. Ambient temperatures outside of this range may adversely affect discharge performance.
3. The discharge capacity declines markedly at temperatures below −20°C, while use at temperatures exceeding 65°C may accelerated battery deterioration.

- **Overdischarge**

1. Avoid overdischarging.
2. Follow the criteria listed below for the cutoff voltage: 0.8V to 1.0V for a single cell, 1.0V per cell for a package of less than five cells and 1.1V per cell for a package of five cells or more.
3. Repeated overdischarge may result in decreased battery service life and battery leakage.

Storage

- **Storage temperature and humidity**

1. Store batteries within the temperature range of −20°C to 35°C where the humidity is low and there is no corrosive gas.
2. Storage at temperatures below −20°C, above 35°C or at high humidity may result in deteriorated performance, leakage or rust.

- **Extended storage**

1. Storage over extended periods can accelerate battery self-discharge and deactivate active materials. Therefore, store batteries in a dry, low temperature environment.
2. After long storage, battery capacity may be reduced. Repeated charge and discharge of batteries should rectify the decrease and result in original capacity. Typically 1–3 years.
3. If white crystalline powder appears on the battery surface, wipe it clean with a dry cloth before use.

Battery Service Life

1. Battery life is generally over 500 charge/discharge cycles, or five to seven years when trickle charged.
2. Battery service life is reduced when charge, discharge, ambient temperature, storage and other conditions are not properly satisfied.

Equipment Design

- **Battery and equipment connection**

1. Do not solder a lead wire directly on to batteries otherwise the heat from the soldering may damage the separators and insulators.
2. Spot-weld a tab to the battery instead, then solder a lead wire to the plate.

- **Parallel connection**

Avoid parallel connection when charging batteries otherwise the charge current becomes uneven, causing undercharge or overcharge, which may result in deteriorated performance.

- **Contact terminal**

1. Use highly alkaline-resistant nickel or nickel-plated steel for contact terminals in battery holders.
2. Do not use materials poor in alkaline resistance (copper, tin, chromium or aluminium) as they may corrode.

- **Battery position in equipment**

Position batteries in equipment so as to avoid heated parts, as battery temperature may rise, resulting in deteriorated performance.

- **Battery assembly inside sealed equipment**

Avoid battery assembly in sealed equipment, as it may cause the generation of hydrogen under certain charge/discharge conditions, resulting in battery explosion. Provide ventilation hole.

- **Disassembly**

1. Never attempt battery disassembly.
2. The electrolyte inside is highly alkaline and causes damage to skin and clothes. If it comes in contact with skin or clothes, immediately rinse with water. If the electrolyte enters the eyes, rinse them with clean water and see a doctor immediately.

- **Handling**

1. Avoid pulling on lead wires and connectors forcefully, as it may damage soldered or spot-welded parts.

- **Short-circuiting**

1. Never attempt to short-circuit batteries. It can cause a dangerously large current flow and damage the equipment or cause the batteries to become hot.

- **Battery disposal in fire**

1. Never throw batteries into a fire, as it may cause explosion or serious accident.

- **Mixed use of batteries**

1. Do not use different types of batteries together. Mixed use of dry batteries, old and new batteries or those different in type and size may cause damage to batteries themselves and equipment.

- **Charging before use**

1. Batteries self-discharge when not in use, and should always be charged before use.

- **Number of connected batteries and arrangement**

1. The maximum number of connected batteries should not exeed 20. Arrange batteries for efficient radiation.
2. When many batteries are connected or when radiation is insufficient, deteriorated performance may result due to battery temperature rise.

- **Battery replacement**

1. When operation time is remarkably reduced even if batteries are properly charged, their service life is completed and they should be replaced with new ones.

9. Glossary of Terms

ACTIVE MATERIAL
The active electro-chemical materials used to manufacture positive and negative electrodes.

ALKALINE ELECTROLYTE
Aqueous solution of alkaline, the ion-conduction medium, normally potassium hydroxide.

AMBIENT TEMPERATURE
The average temperature seen by the battery.

AMPERE-HOUR
Normally used to define capacity of the cell. It is the current in amperes, multiplied by the time in hours, during which current flows from the battery. Also expressed as mili-ampere-hours.

AVAILABLE CAPACITY
The capacity available from the battery based on its state of charge, rate of discharge, and ambient temperature.

BATTERY
Two or more cells, connected together, normally in series. At times, a single cell may be referred to as a battery.

C-RATE
A charge or discharge current rate, expressed in amperes or milliamperes. It is numerically the same as the rated capacity of a cell expressed in ampere-hours.

CAPACITY
The electrical energy available from a cell or battery expressed in ampere-hours. It refers to the discharge of a constant current for a measured time to a specified cutoff voltage (normally one volt per cell), at a specified temperature.

CAPACITY FADE
Loss of capacity from inadequate recharging (See Minimum Charge)

CELL
A cylindrical electro-chemical unit consisting of spiral wound positive and negative electrodes, separator, and electrolyte. Two or more cells are used to make a battery.

CELL REVERSAL
Caused by overdischarge of a battery. It reverses the normal terminal polarities of a cell in a multiple cell battery. Cell reversal normally requires three or more cells in series.

CHARGE
The process of restoring electrical energy to a cell or battery.

CHARGE ACCEPTANCE
Expresses the degree to which the amount of electric charge is effectively accumulated within the battery.

CHARGE EFFICIENCY
Expresses the degree of efficiency of accumulation of charge electricity within the battery.

CHARGE RATE
Normally expressed as a fraction of the C rate, it is the rate at which current is supplied to a cell or battery for recharging.

CHARGE RETENTION
Capacity is gradually lost naturally during storage. Charge retention indicates the percentage of the capacity still remaining.

CLOSED CIRCUIT VOLTAGE TEST
A test method in which the battery is briefly discharged at a constant current, and the voltage is measured.

CONNECTOR
The metal plate connecting each cell electrically in a battery pack. The material is usually nickel.

CONSTANT VOLTAGE CHARGE
A method of charging the battery by applying a fixed voltage, and allowing variations in the current. Normally used for sealed lead rechargeable batteries. Also called constant potential charge.

CONSTANT CURRENT CHARGE
A method of charging the battery using a current having little variation. Normally used for sealed Ni-Cd batteries.

CUTOFF VOLTAGE
The final voltage of a cell or battery at the end of charge or discharge.

CYCLE
A single charge and discharge of a cell or battery.

CYCLE LIFE
The number of cycles a cell or battery provides before failure.

CYCLIC USE
A method of using a secondary battery repeatedly by charging and discharging.

DEEP DISCHARGE
The discharge of a cell or battery to 80 ~ 100% of its rated capacity.

DEPTH OF DISCHARGE
Frequently expressed as a percentage, it is the amount of capacity removed from a cell or battery during discharge.

DISCHARGE
The function of removing current from a cell or battery.

DISCHARGE RATE
Normally expressed as fraction of C, it is the rate at which current is taken from a cell or battery.

DISCHARGE VOLTAGE
The closed circuit voltage of a battery during discharge.

DUTY CYCLE
The normal use of the battery in its application. Includes charge, discharge, and rest intervals.

EDGE-WELDED CONSTRUCTION
An internal construction method in which tabs are welded to the entire edge surfaces of the spirally wound plates in order to lower internal resistance of the cell.

END-OF-CHARGE VOLTAGE
The voltage reached by the cell or battery at the end-of-charge, while the charger is still attached.

END-OF-DISCHARGE VOLTAGE
The final voltage of the cell or battery while the load is still attached.

ELECTRODE
The positive or negative plate holding the active materials in the cell.

ELECTROLYTE
Conducts ions in the cell. Nickel-cadmium cells use alkaline electrolyte; normally potassium hydroxide.

FAILURE MODE
The manner in which a cell fails to function.

FLOAT
Maintains full capacity in a cell or battery by applying a continuous charge. In this instance, the load is connected to the battery and current is provided from the charger.

FORM FACTOR
The phsical configuration of cells in forming a battery or battery pack.

GAS ABSORPTION
The ability of the negative plate to absorb oxygen gas generated within the battery; the greater this ability, the greater the current that can be used for charging.

GASKET
Located in the crimped portion of case and cover, the gasket prevents leakage of electrolyte, also functions as insulation between the case (—) and the cover (+).

"H" TYPE CELL
A cell used for longer life in high temperature ambients. Uses a polypropylene separator. (See: High Temperature)

HIGH-CAPACITY TYPE "E"
Batteries which have a 20% to 30% higher capacity than the standard type cell of the same dimensions.

HIGH-RATE DISCHARGE
A very rapid discharge of the battery. Normally in multiples of C.

HIGH-RATE DISCHARGE & RAPID CHARGE "R/P" TYPE
Battery using the edge-welded construction to permit discharge of high currents in the 10C range or more.

HIGH TEMPERATURE
For the National cell, "high" temperature is in the 45° to 65°C range. Under special test conditions, 85°C can be used for short periods.

HIGH-TEMPERATURE (TRICKLE-CHARGE) TYPE "H"
Batteries for which a continuous trickle charge at high temperature (45°C to 65°C) is possible, with only slight reduction in capacity due to the high temperature; polypropylene is used as the separator.

INTERNAL IMPEDANCE
The resistive value of the cell to an AC current, expressed in ohms. Normally measured at 1,000 Hz at full charge.

INTERNAL PRESSURE
The pressure within a sealed battery; oxygen is generated from the positive plate at the end of charging, causing internal pressure to increase.

INTERNAL RESISTANCE
The resistance within the cell; an element which generates a voltage drop almost proportional to current.

LIFE
The time period until the battery can no longer be used because it has lost its characteristics. (See: Failure Mode.)

LOW TEMPERATURE
For the National cell, "low" temperature in the −20° to 5°C range; usually, discharge performance decreases at low temperature.

LOW VOLTAGE CUT OFF
A sensor designed to end discharge at a predetermined voltage level.

MAINTENANCE FREE
Secondary cells which are not sealed require periodic addition of water. Sealed nicked-cadmium cells do not require such maintenance, and therefore are "maintenance free".

MATCHED CELLS
Cells which have similar initial capacities at time of manufacture. National automatically matches cells, and provides these at no extra cost when making batteries.

MEMORY EFFECT
A reversible failure, occasionally seen, due to repeated shallow discharges. Memory effect is virtually nonexistent in National cells.

MINIMUM CHARGE
The smallest charge that will fully charge and maintain a cell or battery. Use of less than minimum charge can lead to capacity fade.

−ΔV SENSING CUT OFF
A method used to reduce charge current at the end of a 1-hour rapid charge; the voltage decrease from the peak at end of charge is sensed, and charging current is cut off or reduced to C/10.

NOMINAL VOLTAGE
The average value of cell voltage during discharge. Normally 1.2 volts per cell at C/10 cell.

NON-CONTROLLED CHARGE CURRENT
A charge current which can be maintained continuously, regardless of the state of charge of the cell. Varies with cell size and type.

OPEN-CIRCUIT VOLTAGE
The measured voltage of the cell or battery without a load attached.

OVERCHARGE
The continuous charging of a cell after it achieves 100% of capacity.

OVERCHARGE CURRENT
The charge current supplied during overcharge. Cells can accept continuous overcharge at recommended rates and temperatures.

PERMANENT FAILURE
The failure of a cell to achieve at least 80% of its rated capacity after use. Normally caused by internal short-circuiting and loss of electrolyte over a period of time.

POLYPROPYLENE SEPARATOR
Separator used for high-temperature "H" type cells.

PRIMARY CELL
A cell which can be discharged only once.
Example: Manganese-zinc cells, lithium cells.

QUICK CHARGE
Recharging of the battery in 4 ~ 6 hours. Uses C/3 ~ C/4 charging rates.

"R" TYPE CELL
Indicates a type of cell for which a 1C non-controlled charge is possible. With temperature or $-\Delta V$ detection, a rapid charge in 1 to 1.5 hours is possible. A cell used for rapid charging. (See: Rapid Charge)

RAPID CHARGE
Recharging of the battery in approximately one hour. Normally needs special controls.

RATED CAPACITY
The manufacturer's rated capacity of the cell. National cells are rated at C/5 at 20°C. (See: Capacity)

RESEALABLE SAFETY VENT
The resealable safety device built into the cell to release excess pressure and prevent rupture.

REVERSIBLE FAILURE
The failure of a cell to deliver rated capacity, which can be reversed by subjecting it to 1 ~ 3 charge/discharge cycles. (See: Memory Effect)

SECONDARY BATTERY
A battery which can be charged and discharged repeatedly.
Example: Nickel-cadmium batteries, lead-acid batteries

SELF-DISCHARGE
The loss of capacity by a cell while in the stored or unused condition. The rate of self-discharge is affected by ambient temperature.

SENSOR
An element used to detect the temperature in the temperature-detection system.

SEPARATOR
The material separating the spirally wound electrodes. Used to hold the electrolyte. Normally polyamide is used and high-temperature cells use polypropylene.

SERIES CONNECTION CELL
The National cell has a rating of 1.2V. If higher voltage is required, cells must be connected in series. Voltage is then equal to 1.2V x the number of cells.

SHELF LIFE
The life of a cell when stored in the unused condition. National cells can be stored for extended periods of time before use or reuse.

STAND-BY USE
A method of using secondary batteries in which the battery is constantly charged so that it is always ready for use. (See: Float, Trickle Charge)

STANDARD CELL
Cells for which the standard charging current is C/10, and the suggested maximum discharge current is 3 ~ 5C. Standard cells up through size sub-C, can be charged at C/4 to C/3, permitting a quick charge in 4 ~ 6 hours.

STANDARD CHARGE
The normal charge rate used to charge a cell in 14 ~ 16 hours. Normally C/10.

STATE-OF-CHARGE
Expressed as a percentage of C, it is the available capacity of a cell at a given time.

TAB
The terminal or solder lug used as a positive or negative connection from a cell or battery.

TEMPERATURE CUT OFF
A method used during rapid charge to turn off the charger when the battery has reached full capacity. It senses the internal rise in the battery temperature.

TRICKLE CHARGE
Maintains full capacity in a cell or battery by applying a continuous charge, normally at the C/30 ~ C/20 rate. In this case, the load is not connected to the battery. (See: Float)

UNDERVOLTAGE CUT OFF
A sensor which cuts off discharge in order to prevent cell reversal when the battery falls below preset cut off voltage.

VOLTAGE CUT OFF
A sensor used to terminate a charge or discharge when the battery voltage reaches a predetermined level.